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Unmanned Tactical Autonomous Control and Collaboration concept of operations

Rice, Thomas M.

Monterey, California: Naval Postgraduate School

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THESIS

UNMANNED TACTICAL AUTONOMOUS CONTROL AND COLLABORATION CONCEPT OF OPERATIONS

by

Thomas M. Rice
Erik A. Keim
Tom Chhabra

September 2015

Thesis Advisor:	Dan C. Boger
Co-Advisor:	Scot A. Miller

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There is a perceived problem in Marine Corps tactical units regarding technological advancements and cognitive load; specifically, the almost infinite flow of new information on the modern battlefield is overtaxing the human brain. The development of Unmanned Tactical Autonomous Control and Collaboration (UTACC), an alternative warfare concept, could clarify the relationship between technological advancements and cognitive load. UTACC's purpose is to enhance mission accomplishment while simultaneously reducing the cognitive load on the Marine through collaborative autonomy.

This thesis developed a UTACC Concept of Operations that captured the logic, sequencing of operational activities, and initial information exchange requirements for a Marine Corps Warfighting Laboratory provided scenario. Addressing the complexity of UTACC also required an in-depth analysis of collaborative autonomy, human system integration factors, and decision support.

This research finds that, in the early stages, UTACC could be most effective as a scalable decision support tool that automates routine planning processes, improving the efficiency of the small tactical unit. Additionally, this research discovers areas for future work, three of which are: measuring capability gaps, common operational picture management/fusion, and security.

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UNMANNED TACTICAL AUTONOMOUS CONTROL AND COLLABORATION CONCEPT OF OPERATIONS

Thomas M. Rice
Major, United States Marine Corp
B.S. Embry-Riddle Aeronautical University, 2004

Erik A. Keim
Major, United States Marine Corps
B.S., University of Wyoming, 2003

Tom Chhabra
Major, United States Marine Corps
B.S. The Pennsylvania State University, 2000
M.A., Webster University, The University of Texas at El Paso (2008)

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September 2015**

Authors: Thomas M. Rice
Erik A. Keim
Tom Chhabra

Approved by: Dan C. Boger, Ph.D.
Thesis Advisor

Scot A. Miller
Co-Advisor

Dan C. Boger, Ph.D.
Chair, Department of Information Sciences

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ABSTRACT

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LIST OF ACRONYMS AND ABBREVIATIONS

3D	Three Dimensional
5GW	Fifth-Generation Warfare
AAR	After Action Review
AC	Air Carrier
ACE	Aviation Combat Element
AO	Area of Operations
BAMCIS	Begin Planning, Arrange for Reconnaissance and Coordination, Make Reconnaissance, Complete Plan, Issue Order, and Supervise Activities
BF	Blue Force
C2	Command and Control
CCIR	Commander's Critical Information Requirements
CIA	Confidentiality, Integrity, Availability
CID	Combat Identification
CMU	Carnegie Mellon University
COI	Condition of Interest
ConOps	Concept of Operations
COP	Common Operational Picture
COTS	Commercial off the Shelf
CRUSER	Consortium for Robotics and Unmanned Systems Education Research
CTP	Common Tactical Picture
DARPA	Defense Advanced Research Projects Agency
DASC	Direct Air Support Center
DDSP	Degraded Defensive Sensor Posture
DER	Data Exchange Requirements
DOD	Department of Defense
DOSP	Degraded Offensive Sensor Posture
DTED	Digital Terrain Elevation Data
DTG	Date Time Group

E2	Enterprise Engine
EF21	Expeditionary Force 21
FCS	Future Combat Systems
FM	Field Manual
FMC	Fully Mission Capable
FSCM	Fire Support Coordinating Measure
GC	Ground Carrier
GEOINT	Geospatial Intelligence
GPS	Global Positioning System
HRI	Human Robotic Interaction
HSI	Human Systems Interaction
HVI	High Value Individual
IER	Information Exchange Requirement
IFF	Identification Friend or Foe
IPB	Intelligence Preparation of the Battlefield/Battlespace
ISR	Intelligence, Surveillance, and Reconnaissance
JOC	Joint Operations Center
JP	Joint Publication
JREAP	Joint Range Extension Application Protocol
LOS	Line of Sight
MACE	Multi Agency Collaboration Environment
MAGTF	Marine Air-Ground Task Force
MCCDC	Marine Corps Combat Development Command
MCDP	Marine Corps Doctrinal Publication
MCIP	Marine Corps Intelligence Publication
MCISRE	Marine Corps Intelligence, Surveillance, and Reconnaissance Enterprise
MCO	Marine Corps Order
MCOO	Modified Combined Obstacle Overlay
MCPP	Marine Corps Planning Process
MCRP	Marine Corps Reference Publication
MCT	Marine Corps Task

MCTL	Marine Corps Task List
MCWL	Marine Corps Warfighting Laboratory
MCWP	Marine Corps Warfighting Publication
METOC	Meteorology and Oceanography
MIL STD	Military Standard
MPF	Mission Planning Folder
N2C2M2	NATO Net Enabled Command and Control Maturity Model
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NIST	National Institute of Standards and Technology
NMC	Non-Mission Capable
NPS	Naval Postgraduate School
ONR	Office of Naval Research
PLI	Participant, Location, and Identification
PMC	Partially Mission Capable
POI	Person of Interest
ROZ	Restricted Operating Zone
RP	Reports
SA	Situational Awareness
SB	System Baseline
SME	Subject Matter Expert
SoS	System of Systems
SOW	Statement of Work
SU	System Updates
T&R	Training and Readiness
TACC	Tactical Air Command Center
TAOC	Tactical Air Operations Center
TTPs	Tactics, Techniques, and Procedures
UAV	Unmanned Aerial Vehicle
UDOP	User Defined Operational Picture
UGV	Unmanned Ground Vehicle
UIS	User Interface System

USMC	United States Marine Corps
USN	United States Navy
UTACC	Unmanned Tactical Autonomous Control and Collaboration
UxS	Unmanned System
VIRT	Valued Information at the Right Time
VOI	Value of Information
VMF	Variable Message Format

EXECUTIVE SUMMARY

There are a variety of technological advancements in warfare that are designed to aid the warfighter in accomplishing their mission. These advances have also introduced the concept of information overload. Decision makers have to glean specific pieces of information from a vast pool before making a decision. This abundance of information can easily overwhelm the warfighter's cognitive load which leads to degraded mission performance, an unintended consequence. Unmanned Tactical Autonomous Control and Collaboration's (UTACC's) purpose is to enhance mission accomplishment while simultaneously reducing the cognitive load on the operator through collaborative autonomy. UTACC is conceptualized to be armed Marine(s) conducting operations with the assistance of a mix of semi-autonomous unmanned ground and air vehicles. One UTACC system is a triad of a human component, an air component, and a ground component (SOW, 2014).

A. PURPOSE OF RESEARCH AND METHODOLOGY

There is minimal current day research which specifically addresses the phenomenon between technological advancements and cognitive load, although there is a concern that the almost infinite flow of new information is overtaxing the human brain (Bates, 2010). The development of UTACC, an alternative warfare concept, could clarify the relationship between technological advancements and cognitive load. To do this effectively, research must include an in-depth analysis of the operational context; possible missions with associated tasks; collaborative autonomy, human system integration (HSI) factors; and information exchange requirements (IERs). This system requires a high degree of semantic interoperability and innovative technological processes to allow the operator to treat all UTACC components, human or machine, as teammates.

The Marine Corps Warfighting Laboratory (MCWL) initiated the UTACC project in 2013. In its mission statement, MCWL states that it:

> Rigorously explores and assesses Marine Corps service concepts using an integral combination of wargaming, concept-based experimentation, technology assessments, and analysis to validate, modify, or reject the concept's viability, and identify capability gaps and opportunities, in order to inform future force development. ("MCWL," n.d., mission)

MCWL engaged the Naval Postgraduate School to aid in exploratory research into the UTACC concept toward the vision of a "decision-centric, semi-autonomous, distributive, multi-agent, multi-domain robotic system" (SOW, 2014, p. 1).

The first step in this research initiative was this thesis, the development of a Concept of Operations. This exploratory research captured the logic, sequencing of operational activities, and initial IERs for MCWL provided scenario that was limited in scope. A systems engineering approach merged with the Marine Corps troop-leading steps was utilized to structure tasks and sub-tasks within the overall processes of mission planning and execution. This research explored the incorporation of machine components into each of these steps to aid in automated planning and execution.

UTACC, as a future military concept, must be framed by existing doctrine and Tactics Techniques and Procedures (TTPs) in order for MCWL (n.d., mission) to validate, modify, or reject concept viability. Once the Planning and Execution Model (see Appendix A) was complete, a total of 38 tasks and subtasks were identified for the single mission selected. Task Analysis Worksheets (see Appendix D) were created to serve as the central repository to document supporting information related to the Concept of Operations. These worksheets will aid potential system modelers, developers, designers, and future UTACC researches to understand the baseline UTACC Concept of Operations and modify it to meet new requirements.

External reviews and feedback were important to scope the project to something that was manageable for thesis level work. Two external reviews were conducted in 2014 in order to hear different perspectives from individuals who are duty experts in their fields. The first review highlighted the fact that during the early stages of development, UTACC is best utilized as a decision support tool which automates routine processes during mission planning. The second external review highlighted the fact that much of the supporting technology for UTACC already exists; the challenge lies in fusing technologies into a shared common context.

A Proof of Concept demonstration, hosted by Carnegie Mellon University (CMU) in February 2015, proved that with the proper interoperable software, an Unmanned Aerial Vehicle (UAV) and Unmanned Ground Vehicle (UGV) can collaborate to find a target, take a picture of the target, and send that picture to higher headquarters without human assistance. While this demonstration occurred in a controlled environment with CMU equipment, the results justify that UTACC is a viable concept with the capability to mature with advances in technology.

The success of the February 2015 demonstration and all the UTACC-related exploratory research efforts since January 2014 gained the attention of The Honorable Ray Mabus (Secretary of the Navy) and Brigadier General Kevin J. Killea (Commanding General of MCWL). During the 2015 Sea-Air-Space Exposition, both leaders discussed the value of UTACC. Mabus' comments focused on innovation when he stated members of the UTACC initiative "developed a way for an unmanned ground vehicle to communicate seamlessly with an unmanned air vehicle, autonomously identify a target, and perform a mission" (Mabus, 2015, p. 7). Killea's comments focused on the tactical value UTACC brings to the battlefield as the next level in battlefield autonomy (Tucker, 2015). Killea further explained, "The unmanned systems must recognize what they're being told to do, formulate a plan, and then execute a shared understanding of mission requirements…the Marine operator tells the unmanned systems what to do, not how to do it. This frees him up to work on other tasks while the autonomous systems collaborate together on tasks at hand to accomplish the mission" (Tucker, 2015 p. 1).

B. PRIMARY FINDINGS

1. The early stages of UTACC can be designed solely as a planning tool under the condition that sufficient mapping and sensor data is available. Many tasks and processes in the Marine Corps Planning Process are routine in nature and can be automated. Despite the emphasis on automation, the authors are cognizant that human input and supervision is required at specific key points.
2. UTACC software should complete approximately 80% of the planning and allow the humans to refine the last 20%.

3. A risk in automating mission planning is the loss of human tacit knowledge gained in the planning process. This risk can be mitigated through the use of 3D walkthroughs and virtual rehearsals.
4. Much of the technology exists to support the UTACC Concept of Operations, albeit in its infancy. Initiatives should begin immediately to understand the problem set with current technology and evolve to incorporate advances in technology.
5. Explicit feedback loops are necessary in the planning and execution model, this allows machine components to complements natural human thought process.

C. KEY RECOMMENDATIONS FOR FUTURE RESEARCH

1. UTACC is envisioned as a modular system of systems (SoS). Future research efforts need to capitalize on this modular design by incorporating additional missions, conditions, and threats.
2. Addressing capability gaps via metrics is critical to understanding the tactical value of UTACC. This analysis should compare UTACC-assisted units with non-UTACC-assisted units in the performance of a mission(s). Through this process new metrics should be developed to assess human machine collaboration.
3. Future research should address the challenges of Common Operational Picture (COP) management and fusion. This research should address challenges regarding: big data management; information filtering; information push versus pull; COP display hardware selection; and Joint/Interagency COP fusion.
4. UTACC will fail to accomplish any task if the system is not built with security in mind from the outset. A preliminary threat and vulnerability assessment was completed using the Confidentiality, Integrity, and Availability (CIA) triad viewed through the lenses of People, Operations, and Technology (Batson & Wimmer, 2015). Future work should expand on this initial assessment.

D. CONCLUSION

UTACC is a valid exploratory research area that investigates the concept of collaborative autonomy between humans and machine components for the future Marine Corps. This thesis is one of the first seeds to a potentially larger initiative at the enterprise level. The summary of results serves as a starting point for discussion about UTACC's tactical value. The recommendations for further research illustrate the complicated and complex nature of collaborative autonomy. Despite the myriad of challenges with fielding a UTACC capability, stakeholders must always remember that UTACC is conceptualized around employing robotics to enable Marine units to be more combat effective.

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I. INTRODUCTION

This thesis developed an Unmanned Tactical Autonomous Control and Collaboration (UTACC) Concept of Operations that captured the logic, sequencing of operational activities, and initial information exchange requirements for a Marine Corps Warfighting Laboratory (MCWL) provided scenario supporting a Marine small tactical unit. The overarching theme of employing robotics to enable Marine units to be more combat effective led the authors to investigate the evolution of robotic technology and its impact on warfare.

Technological singularity is the point in the future when artificial intelligence has progressed and self-aware computers make decisions too rapidly for humans to comprehend or maintain oversight (Vinge, 1993). While this theory may link to the science fiction genre, Vinge offered two methods through which this breakthrough could be realized: "the development of computers that are awake and superhumanly intelligent; and computer/human interfaces may become so intimate that users may reasonably be considered superhumanly intelligent." The key theme to understand for this thesis occurs prior to the point of technological singularity: humans and machines must collaborate; they must be teammates.

Human-machine integration is already present in warfare. The next generation of warfare brings with it exciting concepts that contain inherent risks. Regardless of the potential risks, the United States Marine Corps (USMC), as an institution, values exploratory research and experimentation in order to shape the future force and prepare for the next generation of warfare. UTACC is one example of this exploratory research.

A. NEXT-GENERATION WARFARE

Hammes (2007) discussed his concept of fifth-generation warfare (5GW), which outlined humans and machines working in concert to achieve a common goal. "5GW will truly be a nets-and-jets war: networks will distribute the key information, provide a source for the necessary equipment and material, and constitute a field from which to recruit volunteers; the jets will provide for worldwide, inexpensive, effective dissemination of the weapons" (Hammes, p. 10).

This same line of thinking was expressed by Singer (2015, p. 1), who stated, "One thing is clear: like the present, the future of war will be robotic." Singer also outlined the challenge of determining robots' intelligence and autonomy along with the debate that reconnaissance drones will naturally evolve to complete kinetic missions. Linking to Vinge, Singer discussed the relationship of cyber-conflict, in which artificial intelligence and software algorithms increasingly make most of the decisions at digital speed, which will impact the future of warfare. Galdorisi (2015) also discussed the importance of balancing autonomy and human interaction. He noted that the rationale of acquiring unmanned platforms needs to focus on the software solution instead of the hardware and capabilities of the physical unmanned system (UxS).

Hammes, Singer, and Galdorisi represent a minuscule portion of scientists, scholars, and warfighters who are forward thinkers on future combat. The authors chose these three scholars specifically to illustrate that a future warfare concept, such as UTACC, is extremely broad in nature and covers, at a minimum: information distribution amongst a variety of agents; concerns with autonomy balance, to include kinetic targeting as systems become more capable; and an emphasis on future system design needs that are initiated at the software level. All this input is needed to truly build a collaborative environment between humans and machines with semantic understanding.

Next-generation concepts require a next generation toolkit (e.g., technology, software, hardware, architecture, security, protocols). UTACC is a next-generation concept. MCWL, the sponsor of this exploratory research, is interested in the tactical aspect of this initiative. This is the reason that exploratory research effort is focused on developing a squad/team level conceptual framework for the UTACC system rather than an enterprise-level solution.

B. INSTITUTION RELEVANCE

The United States Marine Corps values experimentation because "the quality and focus of our exercise and experimentation programs is critical to our readiness, relevance, and success today and in the future" (USMC, 2015a, p. 10). In addition, the *36th Commandant's planning guidance* stated, "The end state of our experimentation will be to develop and nurture the intellectual energy, innovation, and creativity that will enable the Marine Corps to lead tactical and operational innovation" (USMC, 2015a, p. 10). UTACC will require intellectual energy, innovation, and creativity because "any new technology must be stringently evaluated for its potential and must reduce logistical consumption, reduce our footprint and must be more efficient than the gear it replaces" (MCWL, 2013, p. 7).

Expeditionary Force 21 (EF21) is the recently published strategic document for the United States Marine Corps. The Marine Corps Combat Development Command's (MCCDC) Futures Directorate understands that EF21 will lead to the development and exploration of a variety of initiatives, each still in their infancy (MCCDC, 2014). Specifically, the Futures Directorate requires deliverables that guide the Marine Corps capability developers in their efforts to create our future force (MCCDC, 2014). The UTACC Concept of Operations and complementary research efforts, if endorsed by MCWL, qualify as deliverables that can shape the future force.

C. NECESSITY FOR TACTICAL-LEVEL AUTONOMY AND COLLABORATION

There are a variety of technological advancements in warfare that are designed to aid the warfighter in accomplishing their mission. These advances have introduced the concept of information overload. Decision makers have to glean specific pieces of information from a vast pool before making a decision. This abundance of information can easily overwhelm the warfighter's cognitive load which leads to degraded mission performance, an unintended consequence. Figure 1 is a visual depiction of situated cognition as developed by Shattuck and Miller (2006), which illustrates the relationship and processes required to convert data available to information relevant to the decision maker. It is clear that the vast amounts of data available are not digestible by a single individual. There is minimal current research which specifically addresses the relationship between technological advancements and cognitive load phenomenon at the tactical level. However, there is a concern that the almost infinite flow of new information is overtaxing for the human brain (Bates, 2010).

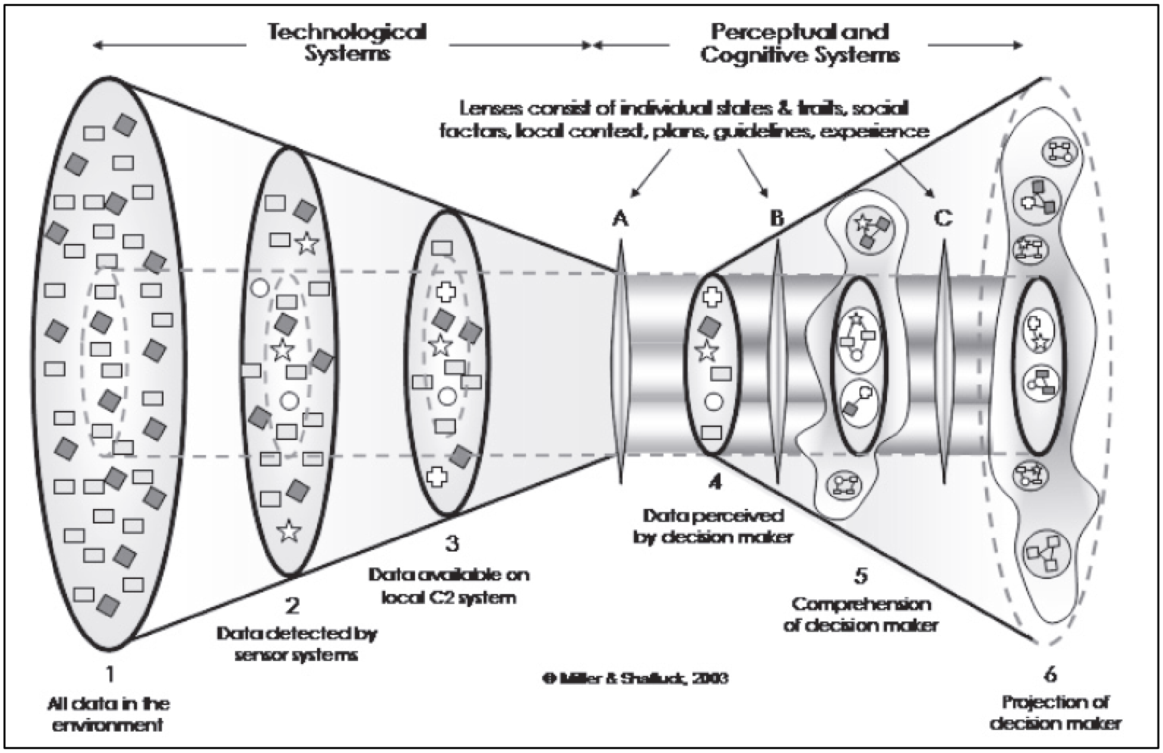

Figure 1. Dynamic Model of Situated Cognition
(from Shattuck & Miller, 2006, p. 6)

UTACC's purpose is to enhance mission accomplishment while simultaneously reducing the cognitive load on the operator through collaborative autonomy between human and machine components. Addressing the complexity of UTACC requires an in-depth analysis of the operational context; possible missions with associated tasks; collaborative autonomy, human system integration (HSI) factors; and information exchange requirements. UTACC will consist of an operator, a ground component, and aerial component acting in a collaborative fashion as a single system to evaluate future Marine Air-Ground Task Force (MAGTF) Operations. This system requires a high degree of semantic interoperability and innovative technological processes to allow the operator to treat all UTACC components, human or machine, as teammates. The underlying questions are defining the operational functions and supporting information exchange requirements to create UTACC.

UTACC must utilize collaboration to increase the quality of information while decreasing time. This will lead to an agile, flexible, and scalable platform which is based on shifting selected tasks currently performed by the operator to the machine components. This is a challenge in itself as shifting human interpretation to the machine components implies mature semantic interoperability and trust. That high level of interoperability is desired because all components of UTACC, human or machine, must share the same mental model in order to accomplish the mission.

The development of UTACC, an alternative warfare concept, could clarify the relationship between technological advancements and cognitive load and identify gaps with current manned mission sets. This process begins by developing a UTACC Concept of Operations which MCWL can analyze to validate, modify, or reject.

D. THESIS IMPACT AND ORGANIZATION

This thesis had three distinct impact areas. First, exploratory research efforts since January 2014 aided in development of the Statement of Work (SOW) found in Appendix A. Second, the authors described a future UTACC vision as a starting point for long-term complementary research efforts. Finally, the authors created reference documents for system modelers during near-term prototyping.

This thesis is organized into four remaining chapters. Chapter II, the literature review, highlights the selected areas of collaborative autonomy, human robotic integration (HRI)/HSI, decision support, and doctrine. This interdisciplinary approach provided the academic rigor to the Concept of Operations. The third chapter, the research methodology, describes the authors' use of common systems engineering practices coupled with Marine Corps mission design framework to develop the Concept of Operations. UTACC specific definitions, assumptions, and constraints are documented as well as doctrinal foundations and results of initial feedback sessions.

The fourth chapter, Concept of Operations, explains the UTACC concept in greater detail through the use of swimlanes. It is not conceivable to document every planning and tactical event for the Concept of Operations in this section, however, Appendices B, C, and D are provided as a reference for more detailed discussions with varying event sequences and states. The last chapter summarizes specific high-level learning points and initiates discussion for complementary research topics.

E. CHAPTER CONCLUSION

UTACC is a valid exploratory research area that investigates the concept of collaborative autonomy between humans and machine components for the future Marine Corps. This thesis is best categorized as one of the first seeds to a potentially larger initiative at the enterprise level. Most importantly, this thesis outlines a methodology for a Concept of Operations and serves as a discussion point for many future research efforts by blending selected portions of academia with military doctrine.

II. LITERATURE REVIEW

Little academic research is strictly focused on small tactical units collaborating with robots. The supporting concepts required to foster this collaborative relationship do exist in academia within the hard sciences (e.g., engineering, computer science, and robotics) and soft sciences (e.g., psychology, philosophy, and sociology). Of note, Information Science is one of the disciplines that link the hard and soft sciences together. The complex nature of Unmanned Tactical Autonomous Control and Collaboration (UTACC) required integration of multiple research areas. Exploration of the UTACC concept required a cross discipline approach focused on: collaborative autonomy, human systems interaction (HSI) / human robotic interaction (HRI), decision support, and United States Marine Corps (USMC) doctrine.

A. COLLABORATIVE AUTONOMY

At the conceptual level, the essence of UTACC is the application of collaborative autonomy. Jameson, Franke, Szczerba, and Stockdale (2005, p. 1) described the purpose of collaborative autonomy as allowing “the human warfighter to command the unmanned vehicles as an active member of a warfighting team, rather than as a detached controller.” As the name indicates, collaborative autonomy is composed of two parts: autonomy and collaboration. Autonomy is the “high degree of autonomy for each individual vehicle, enabling robust and sophisticated capabilities with limited human intervention” (Jameson et al., p. 2). Furthermore, they describe collaborative team operations as “enabling multiple vehicles to operate as a team with the human warfighter; allowing a single human to command multiple vehicles with no more workload than a single vehicle” (p. 2). Jameson et al. (2005) discussed the concept of manned and unmanned helicopter teams working together as teammates to accomplish a specified mission. This same concept is applicable to UTACC, however, UTACC adds additional spohistication by including a small tactical unit as the human component, an unmanned air component, and an unmanned gound component.

1. Autonomy

Autonomy is an extremely difficult term to define because there is a broad spectrum of what is considered to be autonomous. Bruemmer et al. (2004), as well as Glotzback (2004) provided useful definitions regarding automation and the metrics for measuring autonomy levels. The spectrum of autonomy ranges from direct remote control on the low end, to fully autonomous on the high end wherein the unmanned system executes the mission with zero human intervention (Bruemmer et al., 2004). Rather than thinking of a system as either autonomous or manual, it is more useful to view systems as having varying levels of automation, with an autonomous system being *fully automated* (Elliott & Stewart, 2011). The UTACC concept is intended to be a semi-autonomous system; defined by the National Institute of Standards and Technology (NIST) as the mode of operation in which the human and the Unmanned System conduct missions requiring various levels of HRI. Additionally, Siegwart, Nourbakhsh, and Scaramuzza (2011) introduced the fundamentals of autonomy with a focus on robotics and mobility, in this they discussed in detail the primary challenges with mobile robotics, and provided an in-depth analysis of robotic design. Some of the most challenging aspects of robotics include locomotive ability, kinematics, localization, navigation, and the most difficult problem, robotic perception (Siegwart et al., 2011). Robotic perception is the combination of sensing (from cameras or other imaging devices), and the interpretation of this sensed data (Siegwart et al., 2011). A gap which needs to be addressed prior to moving UTACC beyond just a concept is robotic perception limitations.

While little literature exists concerning the specific concept of UTACC, there is an abundance of literature available regarding automation and its potential future applications on the battlefield. Shaker and Wise (1988) provided a detailed account of the history of automation and robotics. The evolution of unmanned systems began in World War I when unmanned biplanes were used as crude versions of guided missiles to attack targets (Shaker & Wise, 1988). Additionally, unmanned carts called *electric dogs* were used to transport supplies to troops in the trenches (Singer, 2009). During World War II the Germans used small, remotely controlled vehicles filled with explosives to augment their outnumbered forces on the eastern front (Singer, 2009). Throughout the Cold War, innovations in unmanned technologies were minimal due to misperceptions in their utility, policy decisions, and a lack of acceptance from generals and politicians (Singer, 2009). Operation Desert Storm was the real beginning of the modern unmanned systems, such as remotely piloted intelligence platforms and mine clearing vehicles (Singer, 2009). However, these systems were only available in very small numbers and had minimal autonomy.

The primary resources likely to be used in developing a Concept of Operations for UTACC address autonomy strictly as it relates to military applications. The overarching document which identifies the current situation and future of autonomy within the Department of Defense (DOD) is *The role of autonomy in DOD systems*. This was written to identify opportunities and challenges in the future implementation of autonomous systems in the military (DOD, 2012). Moving to a higher level on the autonomy spectrum is a challenging problem for the DOD because these systems are primarily a software endeavor which is a pendulum shift away from the typical DOD hardware-centric development and acquisition process (DOD, 2012). Gustavsson and Hieb (2013) developed The Operations Intent and Effects Model, which is a unique way of implementing future Command and Control (C2) systems that enables the military to realize the benefits of automation without the need for continuous human input found in current C2 methodologies. Finally, a paper written by Lin, Beckey, and Abney (2008) provided a creative listing of future missions and task sets for robotic systems, such as surveying damage from biochemical weapons and controlling hostile crowds. Military robotic systems have the potential to serve as a force multiplier on the battlefield due to their ability to do the work of multiple humans without becoming fatigued (Lin et al., 2008).

One potential way of bridging the perception gap is through the concept of collaborative control, in this concept the robot asks the human for assistance when it is experiencing difficulty with a task (Fong, Thorpe, & Baur, 2002). This system model of collaborative control is one in which humans and robots collaborate to achieve goals and a common task (Fong et al., 2002). In this construct the human becomes a resource for the robot to use. For instance, the human will be asked questions about cognition or perception that aids the robot in performance of its tasks. Fong et al. (2002) proposed that this system is more flexible than other models of control in supporting various missions or levels of user capabilities. Fong, Thorpe, and Baur (2003) also asserted that a dialogue between two entities, human and robot, is the most effective form of information sharing. Fong et al. (2003) demonstrated that limited language specific to the task is effective as opposed to the challenges associated with natural language. Fong et al. (2003) described user interface interruption as another limitation in their experimentation with one operator and two robots. The operator was required to stop controlling the functions of one robot in order to answer dialogue questions posed by another robot. They mentioned that increasing the level of autonomy of other robots during this time could temporarily limit additional requests for operator input. UTACC will need to be designed so that the operator's situational awareness and other capabilities are not degraded when interacting with the system components. A final point that is addressed by Fong et al. (2003) is that the dialog between the human and robot helps orient the human when switching between controlling multiple semi-autonomous robots by focusing their attention to where it is most needed.

2. Collaboration

One of the key pioneers who spearheaded much of the change within the Department of Defense (DOD) in the late 1990s was Vice Admiral Arthur Cebrowski (Blaker, 2007). Cebrowski, who later went on to become Director of the Office of Force Transformation under Defense Secretary Rumsfeld, published an article in 1998 titled, "Network Centric Warfare: Its Origins and its Future." Cebrowski believed that by divorcing the military from the concept of attrition warfare, and embracing the concept of network centric warfare, future conflicts could be won faster and cheaper by achieving information superiority over the enemy (Blaker, 2007). Cebrowski's ideas culminated in the DOD release of *Joint Vision 2020*. This document spelled out how networking would be key in achieving an asymmetric information advantage, thus enabling 21st century commanders to make better decisions in a more timely manner (DOD, 2001). A key concept of Joint Vision 2020 was that by fully networking the joint force, information sharing is improved resulting in shared situational awareness (SA). This improved SA at the lower levels would result in friendly decision making cycles moving faster than the enemy can react (DOD, 2001). The idea of net-centric warfare envisioned in the late 20th century can be summarized as the drastic improvement to military C2 through the networking of its forces. History has shown that superior C2 can be a force multiplier in combat, potentially off-setting a technological or numerical disadvantage (Van Creveld, 1985). Cebrowski and Garstka (1998) argued that network-centric warfare is the opposite of attrition warfare, whereas the goal is not to completely annihilate one's enemy, but rather to destroy his will to fight by applying precise combat power at the correct time through an information advantage.

The Marine Corps categorized C2 broadly as either centralized or decentralized (USMC, 1996). The North Atlantic Treaty Organization (NATO) developed the NATO Net Enabled Command and Control Maturity Model (N2C2M2) to establish a hierarchy with five C2 approaches: Conflicted, De-conflicted, Coordinated, Collaborative, and Edge (NATO, 2010). This scalable approach aligns with the concept of collaborative autonomy because there are varying levels of autonomy.

Conflicted C2 means that there is no collective objective between actors. In de-conflicted C2, actors agree to maintain separation (e.g., time, space) in the problem space to avoid adverse effects. Coordinated C2 means that actors may actually communicate while in action, and may cross agreed upon boundaries with consent from the other actors. Collaborative C2 means that actors have shared intent, and have enough situational awareness that they can share resources, and boundaries to accomplish their tasks while not conflicting with another actor's tasks. Forces that are collaborative have the advantage of being more agile and efficient. The objective of Edge C2 is to enable the collective to self-synchronize to accomplish a common goal. This implies a level of understanding about all other actors, associated tasks, and intentions in the problem space. This requires a level of sophistication seldom observed in human military units and not realistically anticipated in unmanned systems at this time. Therefore, the vision of UTACC requires a collaborative C2 approach (NATO, 2010).

The following quotation from the N2C2M2 discusses the different of C2 approaches shown in Figure 2.

There is a gap between Conflicted and De-Conflicted C2 and a gap between Collaborative and Edge C2. De-Conflicted, Coordinated, and Collaborative C2 are shown without gaps between them. This is because the exact boundaries between De-Conflicted and Coordinated and between Coordinated and Collaborative are difficult to define precisely. De-Conflicted C2, Coordinated C2 and Collaborative C2 represent increasingly capable C2 approaches that correspond to greater allocation of decision rights to the collective and increasing levels of information sharing; which increases awareness and shared awareness. Edge C2 then also stands by itself. It is achieved only by the exploitation of a critical level of shared awareness, and shared intent. (NATO, 2010)

C2 Approach	Allocation of Decision Rights to the Collective	Patterns of Interaction Among Participating Entities	Distribution of Information (Entity Information Positions)
Edge C2	Not Explicit, Self- Allocated (Emergent, Tailored, and Dynamic)	Unlimited As Required	All Available and Relevant Information Accessible
Collaborative C2	Collaborative Process and Shared Plan	Significant Broad	Additional Information Across Collaborative Areas/Functions
Coordinated C2	Coordination Process and Linked Plans	Limited and Focused	Additional Information About Coordinated Areas/Functions
De-Conflicted C2	Establish Constraints	Very Limited Sharply Focused	Additional Information About Constraints and Seams
Conflicted C2	None	None	Organic Information

Figure 2. The Different C2 Approaches (from NATO, 2010, p. 64)

B. HUMAN SYSTEMS INTERACTION/HUMAN ROBOTIC INTERACTION

The permitted level of autonomy of UTACC will drive the development of system behaviors. HSI/HRI is critical to UTACC because it physically links the human component and machine component together to collaborate and exchange information. As systems become more intelligent and sophisticated, it has been increasingly possible for human operators to stay *on the loop* (i.e., supervisory control) rather than *in the loop* (i.e., active control) (Chen & Barnes, 2014). Staying on the loop is not easier than being in the loop without the appropriate system interaction/interface to support the human operator (Chen & Barnes, 2014). Data from the sensors needs to be relayed to the C2 workstations and displayed on the workstations in a manner that does not overload decision makers (Shattuck & Lewis Miller, 2006). Decision makers need to be provided information in a way that aids their perception, comprehension, projection, and decisions to facilitate the accomplishment of the system's goals (Shattuck & Lewis Miller, 2006). One way to make the system more intelligent is by integrating a computational cognitive model with a robotic system. This allows the cognitive model to do the *thinking and reasoning* aspects of the task and the robot's low-level mobility code to perform routine functions like the movement and control of its effectors (Trafton et al., 2006).

UTACC will be required to push and pull information to ensure tasks are received, understood and accomplished based on direction from human teammates. Gold (2009) stated four areas of information exchange required in the information pipeline: robot to human, environment to robot, human to robot, and robot to environment. UTACC design will require analysis of these four areas of information exchange with the addition of a fifth area, robot to robot. Robot teammates must be "designed with high-levels of autonomy and well-developed coordination skills to aid humans in unpredictable environments" (Groom & Nass, 2008, p. 1). Groom and Nass developed the following questions to set a framework for a human robot interaction model:

- Which human inabilities can the robot perform?
- What organizational structure best supports both human and robots?

Sensors, processors, and effectors will enable the system to interact with the environment, but communication links will enable the robot to transmit and receive information from other robots and humans. Designers need to ensure sufficient sensors are available to detect data in the environment in which the system will need to perform its designated tasks (Shattuck & Lewis Miller, 2006).

The ability of UTACC's human interface to support operator decision-making is critical to mission success (Micro Analysis and Design, Inc, 2003). A large amount of research has been conducted to understand human thought and information processing capabilities in order to design effective user interfaces that support user performance

(Micro Analysis and Design, Inc, 2003). Designers must use this research to ensure that designs do not have unintended consequences for the users (Micro Analysis and Design, Inc, 2003). Results from the evaluation of a human / robotic company-sized unit indicate that cooperative interface agents, the same principle as collaborative control described by Fong et al. (2002), may be a practical technique for reducing C2 complexity (Wood, Zaientz, & Lickteig, 2006). Designers need to identify human-robotic interaction attributes and associated variables that should be captured when modeling supervisory control unmanned systems (Wood, Zaientz & Lickteig, 2006). Models should be developed using team variables (i.e., composition and level of autonomy) and operator variables (i.e., attention allocation strategies and situational awareness level) to aid in user interface development (Nehme, 2009).

C. DECISION SUPPORT

The combination of autonomy and HSI/HRI directly link to the concept of decision support tools. UTACC's planning capabilities are inherently tied to planning processes and decision making cycles which makes this a relevant area of study. Decision support tool design is challenging for a variety of reasons: information quantity/quality, time received, and context. These issues are not exclusive from each other. The first issue is the quantity and type of information. Bates (2010) summarized information overload in the context of the desire to maintain information superiority over an adversary. Bates (2010) further argued that the vast amounts of information available/required intended to assist the commanders actually degraded the decision making process instead of improving it. "It demonstrates the cognitive capability of the human brain is limited and the disparity between the finite ability of the brain and the almost infinite flow of new information is overtaxing the human brain" (Bates, 2010, p. 14). The quantity of information can be organized and managed by a military information system, however a decision support tool is required to prioritize and filter the information, not just organize it.

The second issue is the value of the information at the time received. "In order to turn large amounts of potentially disparate information into useful knowledge to aid situational awareness (SA), it is vital to have some way to judge the importance of individual pieces of information. This importance is called the Value of Information (VoI) metric" (Newcomb & Hammell, 2013, p. 143). A complementary concept to VoI is Valued Information at the Right Time (VIRT). Hayes-Roth (2006, p. 9) stated that a high level design approach must be implemented to answer the following: "who needs what information; how does that information find them; how do we assure receivers are not glutted by a deluge of low-value data and consumed by attendant low-value tasks?" Even though Hayes-Roth argued for a high level design approach, the concepts of his theory are sound at the tactical level. The time critical nature of information flow can be simplified by prioritizing the information that is mission critical over that which is routine. This prioritization is familiar to military planners via the Commander's Critical Information Requirements (CCIR): "An information requirement identified by the commander as being critical to facilitating timely decision making" (DOD, 2010, p. 41). The Marine Corps amplification is: "Information regarding the enemy and friendly activities and the environment identified by the commander as critical to maintaining situational awareness, planning future activities, and facilitating timely decision-making" (USMC, 2011, p. II-16).

VIRT's underlying principle is that high value information is transmitted / received by the network, with the appropriate priority, to the correct recipient(s) (Hayes-Roth, 2006). This prioritization will mitigate issues with information overload. He linked the CCIR concept with the term condition of interest (COI), which is a "type of worrisome event that warrants immediate notification" (Hayes-Roth, 2006, p. 4). This COI concept in the VIRT methodology reduces the flow of information to the operator by letting system capabilities address routine monitoring tasks.

The last major issue is arguably the most complex because of the attempt to put information in the correct context for human understanding which links VoI to the quality of the decision. Newcomb and Hammell (2013, p. 144) mentioned that "determining which information is valuable is a daunting task complicated not only by the sheer amount and diversity of information, but also by the subtle fact that the value of a piece of information will be determined by mission context." They further explained that determining the VoI is currently a human-centric process. Ashok and Tesar (2008) amplify this comment as they discussed how human beings are able to make quick and accurate decisions in complex scenarios if they have access to all the relevant information. The obvious challenge to address is the methodology for how a decision support tool can serve its purpose to display the correct information at the correct time for a decision-maker considering the inherent variability (e.g., type, structure, size) of messages. Newcomb and Hammell (2013) developed a model which uses custom algorithms based on source reliability, information content and timeliness in a simulated environment. This model proposed a methodology to improve decision support, but has yet to be tested outside of a simulated environment with large volumes of message traffic. As their research refines and progresses, Newcomb and Hammell's (2013) goal is to develop a working model and increase the level of complexity with higher volumes of varied message traffic. Validation of their body of work will occur when research extends into the physical environments (Newcomb & Hammell, 2013).

D. DOCTRINE

UTACC must be nested within the Marine Corps Task List (MCTL) in order to evaluate any current capability gaps and/or to find efficiencies compared to current day employment. This unique research will create bridges between current day concepts and technologies with those concepts and technologies prevalent in the science fiction genre. The theory to create this collaborative autonomy, interoperability, and architecture does not exist in Marine Corps doctrine. The capstone publication of Marine Corps Doctrinal Publication *Warfighting* (MCDP 1) along with the keystone publications of *Intelligence* (MCDP 2), *Expeditionary operations* (MCDP 3), *Logistics* (MCDP 4), *Planning* (MCDP 5), and *Command and control* (MCDP 6) serve as the foundational documents for the Marine Corps' fundamental ethos and overarching warfare beliefs. These documents were last revised in the late 1990s; however, the content remains salient to all Marines.

The future vision of the Marine Corps is described in *Expeditionary force 21* (EF21) published in March 2014. This document is "more than a vision – it is also an actionable plan and a disciplined process to shape and guide our capability and capacity decisions” (USMC, 2014a, Foreword). Regarding technological advances, EF21 outlines a modern force attribute that will preserve a quantitative edge over opponents and exploit innovative concepts and approaches (USMC, 2014a). UTACC seeks the quantitative edge and is clearly innovative; EF21 justified these research efforts.

A mature UTACC system requires full integration of warfighting functions (intelligence, maneuver, fires, logistics, force protection, command and control). However, the initial development must begin with the intelligence warfighting function and build into command and control. The research focus for UTACC development should start with analysis of the Marine Corps Tasks (MCTs) listed in Table 1 and their associated metrics and conditions to measure performance. By design, all MCTs in Table 1 are a subset of MCT 2 (Develop Intelligence), which preserves initial focus on the intelligence warfighting function. This framework is vital to ensuring the scope of this research is feasible and that UTACC development is incremental in nature.

Table 1. Preliminary UTACC MCTs of Interest (after USMC, 2015b)

MCT	Description
2.2	Collect Data and Intelligence
2.2.1	Conduct Tactical Reconnaissance
2.2.3	Conduct Terrain Reconnaissance
2.2.5	Conduct Aviation Intelligence Collection Activities
2.7	Conduct Ground Reconnaissance and Surveillance

E. CHAPTER CONCLUSION

Creating a system that combines humans and semi-autonomous unmanned systems in a collaborative manner is a new endeavor. While this review of literature is not all encompassing, the authors used the information gained on collaborative autonomy, HSI/HRI, decision support, and USMC doctrine as a foundation to begin this endeavor. The academic background is critical to understanding the complexities inherent with the concept of collaborative autonomy between human and machine components.

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III. RESEARCH METHODOLOGY

The Marine Corps Warfighting Laboratory (MCWL) initiated the Unmanned Tactical Autonomous Control and Collaboration (UTACC) project in 2013. MCWL "rigorously explores and assesses Marine Corps service concepts using an integral combination of wargaming, concept-based experimentation, technology assessments, and analysis to validate, modify, or reject the concept's viability, and identify capability gaps and opportunities, in order to inform future force development (MCWL, n.d., mission)." As the project sponsor, MCWL engaged the Naval Postgraduate School (NPS) to aid in exploratory research and refine the initial statement of work (SOW). The final, long term UTACC configuration is a, "decision-centric, semi-autonomous, distributive, multi-agent, multi-domain robotic system" (SOW, 2014, p. 1).

With this endstate in mind, the authors discovered that the research methodology would require processes from various two distinct sources. A combination of systems engineering approaches and United States Marine Corps (USMC) troop-leading steps formed the backbone that mapped the logic and information flow. This backbone was further enhanced by definitions, assumptions, constraints, and doctrinal foundations based on a prescribed mission. Feedback through internal and external reviews aided in thinking through conceptual challenges and scoped the Concept of Operations to a manageable state given numerous variables.

A. BASIC SYSTEMS ENGINEERING PROCESS

The purpose of UTACC is to enhance mission accomplishment while simultaneously reducing the cognitive load on the operator through collaborative autonomy. Addressing the complexity of UTACC required an in-depth systems analysis of: the operational context, possible missions with associated tasks, human system integration (HSI) factors, and information/data exchange requirements. The authors relied heavily on Benjamin S. Blanchard's *Systems Engineering Management* (4th edition) for a primer on all matters related to systems engineering. In Blanchard's quoted text, the International Council on Systems Engineering defined a system as:

> A “system” is a construct or collection of different elements that together produce results not obtainable by the elements alone. The elements, or parts, can include people, hardware, software, facilities, policies, and documents; that is, all things required to produce system-level results. The results include system-level qualities, properties, characteristics, functions, behavior, and performance. The value added by the system as a whole, beyond that contributed independently by the parts, is primarily created by the relationship among the parts; that is, how they are interconnected. (Blanchard, 2008, p. 3)

Based on that definition the UTACC system will consist of a small tactical Marine unit, one or more ground components, and one or more aerial components working in a collaborative fashion. This system requires a high degree of semantic interoperability and innovative technological processes to allow the operator to treat all UTACC components, human or machine, as teammates.

As envisioned, UTACC will be a complex system of systems (SoS). Jamshidi (2009, p. 2) defined a SoS as “large scale integrated systems that are heterogeneous and independently operable on their own, but are networked together for a common goal.” In addition each component of UTACC is itself a SoS, and UTACC will need to function as a component within larger Marine Corps’ Command and Control (C2) architectures to ensure unity of effort within the area of operations (AO). Each UTACC component will be capable of independent operations based on platform type, but will contribute within the SoS structure to achieve the holistic mission objectives. This thesis focuses on the overarching concept of employment and integration of major subcomponents and associated Information Exchange Requirements (IER). This approach allows the development of a device/technology agnostic concept.

1. Scope

The first step in this research initiative was the concept design, hereafter known as the Concept of Operations. This thesis focused exclusively on the Concept of Operations which captured the logic, sequencing of operational activities, and initial IERs for a single mission limited in scope. The outputs of this Concept of Operations will form the basis for a Proof of Concept demonstration. Per their mission statement, MCWL will determine if further investment in the UTACC initiative is warranted based on the

Concept of Operations and Proof of Concept demonstration. Further investment translates to funding and resource allocation to support subsequent steps of the systems engineering management process found in Figure 3.

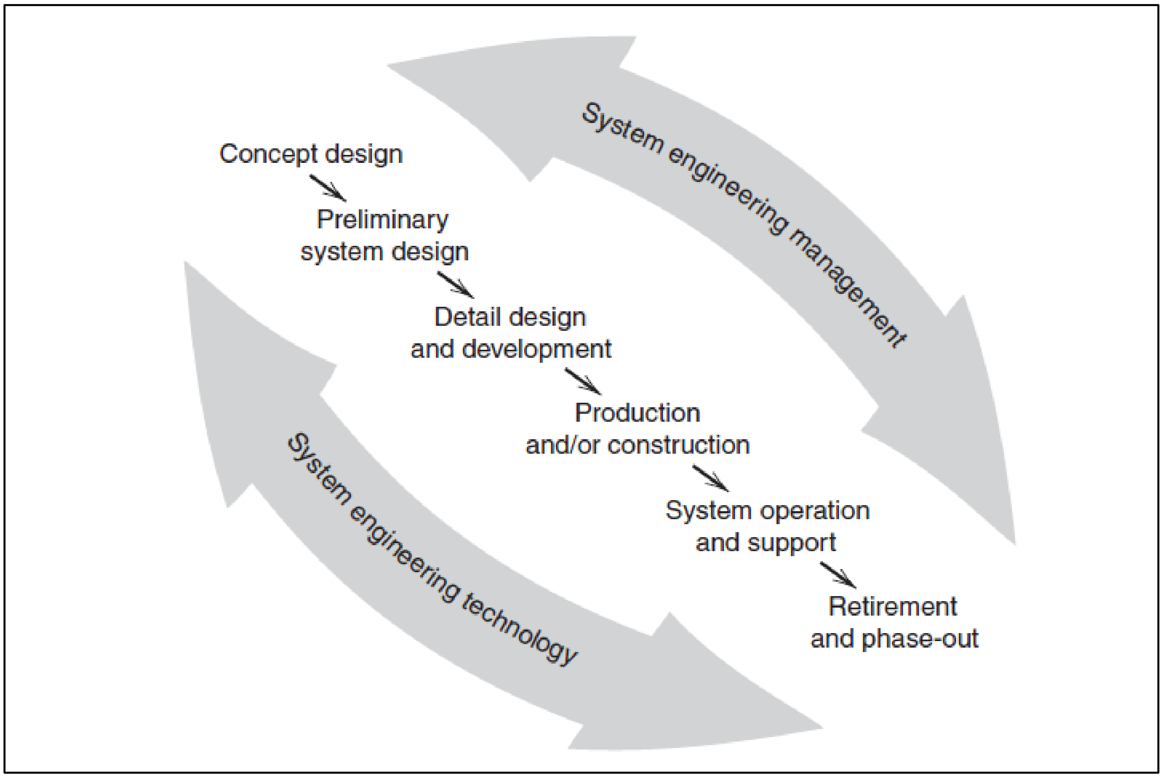

Figure 3. Management and Technology Application to the System Engineering Process (from Blanchard, 2008, p. 45)

2. Use of Systems Engineering Process

Blanchard summarized the systems engineering process (see Figure 4), which the authors used as a guide to structure this thesis. The steps that were most applicable to this thesis were: definition of problem, operational requirements, and functional analysis. The entire process also incorporated feedback mechanisms as an important element of concept generation.

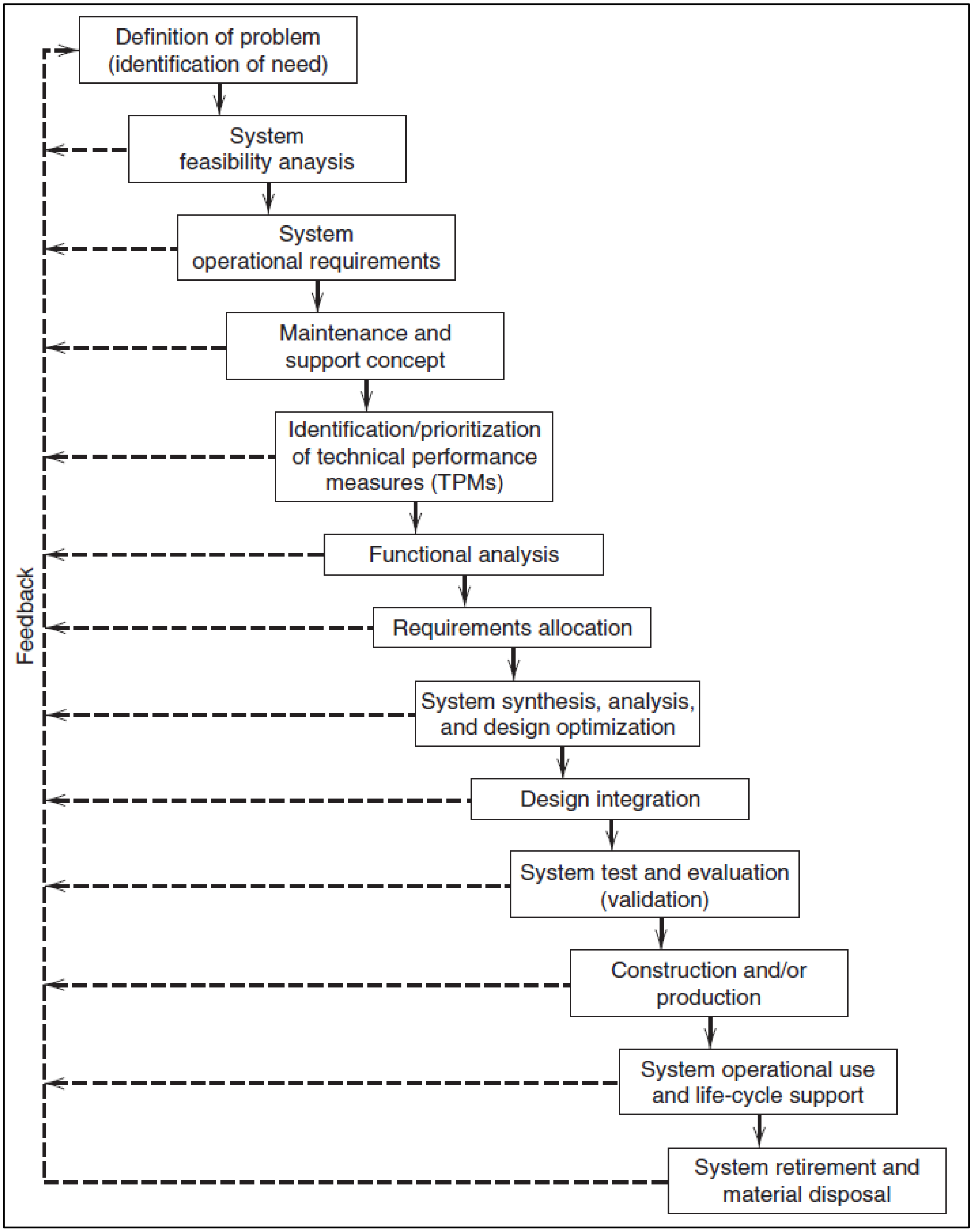

Figure 4. The System Engineering Process in the Life Cycle
(from Blanchard, 2008, p. 52)

3. Definition of Problem

The current use of unmanned systems within the Department of Defense (DOD) most often requires multiple human operators to tele-operate one system. These remotely controlled missions limit that operator's attention to the unmanned system reducing his situational awareness. In a combat situation this lack of situational awareness means that additional human resources are required to provide force protection measures.

a. Operational Requirements

Blanchard (2008, pp. 57–59) outlined Operational Requirement to include the following information. The authors' focus areas for framework development are denoted by "**."

- Operational distribution or deployment **
- Mission profile(s) or scenario(s) **
- Performance and related operational parameters
- Utilization requirements
- Effectiveness requirements
- Major system interface or interoperability requirements **
- Environment ** (Blanchard, 2008, pp. 57–59)

b. Functional Analysis

Blanchard stated,

> An essential element of early conceptual and preliminary design is the development of a functional description of the system to serve as a basis for the identification of the resources necessary for the system to accomplish its objective(s). A function is a specific or discrete action (or series of actions) necessary to achieve a given objective … At this point, the objective is to specify the "whats" and not the "hows"; that is, what needs to be accomplished versus how it is to be done. (2008, p. 71)

The functional analysis is the heart of the concept generation. Using this methodology the authors explored subcomponent interactions focused on information exchange to support the small tactical unit.

c. *Steps Omitted*

A system feasibility analysis and identification of technical performance measures were not conducted because the perfect technology assumption was used to allow for more open minded solutions to be developed to meet the technology agnostic requirements. The perfect technology assumption is defined by Satzinger, Jackson, and Burd (2012, p. 76) as “the assumption that a system runs under perfect operating and technological solutions.” The maintenance and support concept was not considered along with all remaining steps following functional analysis to maintain focus on concept generation.

B. TROOP-LEADING STEPS

This thesis leveraged the Marine Corps’ troop-leading steps of: Begin Planning, Arrange for Reconnaissance and Coordination, Make Reconnaissance, Complete Plan, Issue Order, and Supervise Activities (BAMCIS) as a foundation to analyze and build the functional steps of UTACC. In the following quotation, the USMC defined these troop-leading steps:

> The troop-leading procedures listed below are aids in preparing for and executing assigned missions. They assist squad and fire team leaders in making the best use of time, facilities, and personnel. All the steps should be considered, but depending upon the mission and time available, the degree of consideration for each will vary.
>
> Begin Planning. When an order is received, the squad leader considers the time available to him. In so doing, he uses a planning sequence called reverse planning, meaning that he starts with the last action for which a time is specified (e.g., an attack) and works backward to the issuing of his order. This helps ensure that enough time is allowed for the completion of all necessary actions. During this stage, he also analyzes the terrain and the friendly and enemy situation. From his analysis, he formulates a preliminary plan of action to accomplish the mission. This plan is only tentative and will often be changed.
>
> Arrange for Reconnaissance and Coordination. The squad leader selects a route and prepares a schedule for reconnaissance and coordination with adjacent and supporting units. Normally, he takes his fire team leaders and the leaders of any attached crew-served weapons teams with him on his reconnaissance.

> Make Reconnaissance. On his reconnaissance, the squad leader completes his estimate of the situation. Prearranged meetings with adjacent squads and supporting units are held as scheduled. He notes how the terrain affects his preliminary plan and adopts, alters, or ejects it as necessary. While on his reconnaissance, he selects advantage point from which to orient his fire team leaders.
>
> Complete Plan. Upon his return from the reconnaissance, the squad leader completes his plan of action. He then prepares notes to be used in issuing his order.
>
> Issue Order. If possible, the squad leader issues his order to the same personnel he took with him on his reconnaissance from the vantage point he had selected earlier. If this is not possible, the team leaders are oriented from maps, sketches, or an improvised terrain model. He issues his order using the five-paragraph order sequence and includes everything his fire team and attached weapons leaders ned to know.
>
> Supervise Activities. The squad leader continuously supervises his unit to ensure that his order is carried out as intended. (2002, pp. C1-C2)

BAMCIS was used as a framework for this thesis due to the familiarity that all Marines have with this concept. UTACC explored the incorporation of machine components into each of these steps to aid in automated planning and execution. Figure 5 is a visual depiction of how the outputs of one step become the inputs of follow on steps, with continuous feedback in the Supervise Activities step.

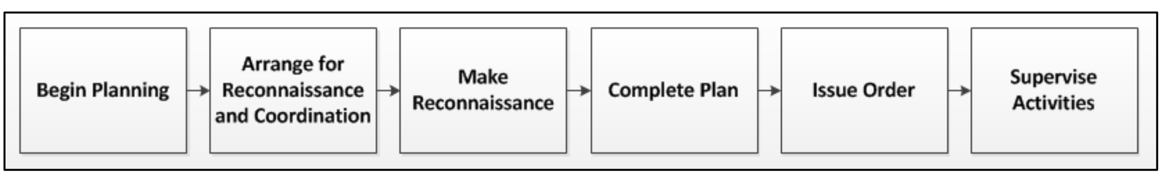

Figure 5. Troop-Leading Steps (BAMCIS)

Blanchard (2008, p. 72) explicitly utilized the idea of feedback loops in this traceability of requirements in functional analysis. The authors adopted explicit feedback loops into the UTACC Planning and Execution Model (see Appendix B).

C. DEFINITIONS

During the early stages of the concept development, the following terms were established to allow for consistency when discussing the concept with the many stakeholders involved in the UTACC project.

Small tactical unit—a Marine Corps infantry fire team, infantry squad, or reconnaissance team.

UTACC—armed Marine(s) conducting operations with the assistance of a mix of semi-autonomous unmanned ground and air vehicles. One UTACC system is a triad of human component, air component, and ground component. (SOW)

Human Component—envisioned to be the small tactical unit leader. UTACC should also be able to work with and provide input to and receive direction from all members of a small tactical unit.

User Interface System (UIS)—a combination of devices that stimulate multiple senses in the human. For example this might allow him to: see a map of the operations area or live video of a specific person of interest; hear a warning informing him that a component has experienced a critical system failure; feel a warning that enemy forces have been detected nearby. In addition to providing input to the human the UIS will also receive input from the human and then relay that input to all the other UTACC components. The human inputs can also come in a variety of ways: hand and arm signals directing the tactical movement of UTACC; verbal messages given to human teammates as well as UTACC components; touch gestures/drawings on a UTACC generated map or preformatted report.

Air Carrier (AC)—an unmanned ground vehicle capable of carrying, launching, recovering, and refueling multiple unmanned air vehicles (UAVs). In addition the AC will be capable of carrying additional supplies (e.g., ammunition, food) for the small tactical unit as well as acting as a communications relay for the UTACC components. This vehicle will be capable of high speed travel over rough terrain and off-road areas.

Unmanned Air Vehicle (UAV)—an aerial platform capable of carrying any number of sensors to support mission specific intelligence, surveillance, and reconnaissance (ISR) requirements and capable of vertical takeoff and landing. The UAV will be capable of serving as a vital communications relay node between geographically separated ground components.

Ground Carrier (GC)—an unmanned ground vehicle capable of carrying, deploying, and recovering multiple unmanned ground vehicles (UGVs). In addition the GC will be capable of carrying additional supplies (e.g., ammunition, food) for the small tactical unit as well as acting as a communications relay for the UTACC components. This vehicle will be capable of high speed travel over rough terrain and off-road areas.

Unmanned Ground Vehicle (UGV)—mission-specific unmanned systems capable of performing discrete ISR missions. The UGVs, similar to the UAVs, could have a variety of sensors to support mission specific ISR requirements.

Cue—a notification issued by the UIS to the Human Component when human intervention is not required.

Alert—a prompt issued by the UIS to the Human Component requiring human intervention.

D. ASSUMPTIONS

There were key assumptions which needed to be accepted prior to developing a UTACC Concept of Operations. The first of which was to remain technology agnostic. Otherwise, it could be tempting to visualize specific hardware components when developing a future concept such as UTACC. This type of thinking is detrimental to the evolutionary nature of the UTACC design process. Additionally, much of the technologies which will ultimately become hardware components of a future C2 system such as this are in their infancy. Rather than visualizing specific hardware components such as the types of vehicles or sensors, the focus of this concept is on operational sequencing and IERs.

Another assumption made was that the Marine operators are fully trained and proficient with the system. The introduction of any new weapon system creates challenges due to the need to update tactics, techniques, and procedures (TTPs) and training and readiness (T&R) manuals. This concept was generated under the assumption that the program is far enough along in its life cycle that these challenges have been resolved. This allowed the authors to creatively explore a wide spectrum of functionality options without being stifled by the learning curve of the operator.

The ultimate goal of this concept is for the system to be fully integrated at the small unit level, capable of performing a broad spectrum of mission sets and warfighting functions. However, for the purposes of this Concept of Operations, it was important to scope down to a single mission and focus on the intelligence warfighting function. Spiral design was an integral aspect of this project. Once the initial mission has been validated, the concept can be expanded to include additional mission sets. Additionally, many variables were simplified to assist with the development of the initial mission: permissive environment (i.e., no immediate enemy threat) and favorable conditions (e.g., sky clear, calm winds, daytime, visual flight rules, highly navigable terrain).

In order to scope the project down to a single mission and warfighting function while also allowing for future growth of the concept, UTACC is envisioned to be highly modular. This modularity is both in the variety of missions which can be executed, as well as with specific hardware components. For example, a given mission might require a specific sensor when others do not. Modularity would allow the small unit to piece together the appropriate components required for a specific mission. Additionally, expansion of this concept becomes easier if missions are viewed as modules which can be incorporated throughout the design process.

Despite the fact that this research needs to be conducted technology agnostic, there are certain technical aspects of UTACC which were assumed in order to move forward with a Concept of Operations. These concepts included the perfect technology and perfect solution assumptions which prevented stagnation over issues such as: security, error/exception conditions, bandwidth, interoperability, data management, processing power, and storage capacity. These issues will be incorporated as this concept is refined. Finally, the authors decided the robotic components will not be armed to simplify the concept and prevent a protracted ethical debate.

E. CONSTRAINTS

During early conceptualization of the UTACC vision, several baseline requirements became evident to the primary UTACC stakeholders. The statement of work found in Appendix A outlines details of the final system required capabilities. These are summarized:

- Organic mapping and obstacle identification
- Distributive architecture and processing
- Adaptive behaviors enabling minimal operator workload
- Autonomous system diagnostic monitoring
- Modular architectural infrastructure
- Easily maintained and serviced
- Use collaborative C2 capabilities
- Operate on organic power

UTACC is designed to improve the tactical warfighter's capabilities and is intended to be used by small tactical units. Because of this, UTACC must be designed so that any Marine is capable of using the system with minimal specialized training. This Concept of Operations must enable increased situational awareness through the collaboration of components rather than result in information overload for the human operator. Operator workload can be further reduced by incorporating adaptive system behaviors

An important constraint for this Concept of Operations is that all functionality is to be distributed, such that the loss of one component of the UTACC triad does not limit the ability of the other two to continue the mission. Distributing storage and processing capacity throughout the architecture of UTACC enables graceful degradation in the event that individual components fail or are destroyed. This is also important because the concept is intended to be modular such that there are mission dependent scenarios when certain components are not required and can be stowed.

UTACC must be able to organically map its surroundings and perceive the environment to enable autonomous navigation. Robotic perception is the combination of sensing, and the interpretation of this sensed data (Siegwart et al., 2011). Perception is a key technology gap which must be bridged prior to the UTACC concept becoming a reality. Current robotic systems are being developed that are capable of interpreting data in order to adequately perceive the environment for autonomous navigation.

UTACC must allow one operator to use multiple unmanned systems rather than the current systems which require a minimum of one human operator for one unmanned system. An increase in autonomy can reallocate manpower to other mission critical and routine tasks. Because of this reduction in dedicated operators, maintenance functions will need to become highly automated. Robotic components must be able to autonomously monitor and diagnose sub-component system health while being easily maintained and serviced by the small tactical unit. Finally, components must operate on an organic power source due to the expeditionary nature of the UTACC vision.

F. ROLE OF DOCTRINE

The DOD defined doctrine as "fundamental principles by which the military forces or elements thereof guide their actions in support of national objectives. It is authoritative but requires judgment in application" (DOD, 2010, p. 71). While each component of TTPs has an individual definition, the central theme is that TTPs are the ways and means to accomplish prescribed missions and functions. UTACC, as a future military concept, must be framed by existing doctrine and TTPs in order for MCWL (n.d., mission) to validate, modify, or reject concept viability. The incorporation of military doctrine fused with complementary efforts in academia resulted in deliberate concept development.

The linkages of doctrine and TTPs were documented using Task Analysis Worksheets. The Task Analysis Worksheets, derived from a Marine Corps Planning Process job aid, were tailored by the authors specifically for UTACC. These worksheets, found in Appendix D, are divided into three main sections: Administrative Data, Planning Factors, and UTACC Actions. The details of each section are described in Table 2.

Table 2. Task Analysis Worksheet Structure

Administrative Data	
Task Name	Self-Explanatory
Task Abbreviation	Author generated abbreviation for the task
Catalog Number	Author generated catalog number for the task
Parent/Previous Task(s)	Catalog number of Parent/Previous Task(s)
Child/Subsequent Task(s)	Catalog number of Child/Subsequent Task(s)
Parallel Task(s)	Catalog number of Parallel Task(s)
Task Summary	A non-technical description of what must be accomplished to complete the task
Reference Documents	Self-Explanatory
Planning Factors	
Threat Analysis	A synopsis of the role of the threat/adversary that affect task performance
Conditions	The variables of the environment that affect task performance
Assumptions	Events assumed to be true in the absence of facts in order to continue planning
Resources	The components and subcomponents of UTACC that will be utilized to complete this task
Specified Tasks	Tasks specifically given by higher headquarters
Implied Tasks	Tasks not specifically stated by higher headquarters but are necessary to accomplish specified tasks
Limitations	Constraints: What must be done Restraints: What cannot be done
Shortfalls	Resources required to accomplish the task that are not organic to UTACC
UTACC Actions	
Inputs	Elements required for the task to be accomplished (e.g., tangible resources, information requirements, etc.)
Process	A non-technical description of the process to assist the modeling team
Outputs	The results of the process given specific inputs
Associated IERs	A list of relevant IERs affected during the process

The Task Analysis Worksheets served three purposes. First, it was the central repository to document supporting information related to the Concept of Operations. Second, it will aid potential system modelers, developers, and designers to understand the authors' intention and context behind the Concept of Operations. Finally, future UTACC researchers will need to understand the baseline UTACC Concept of Operations and modify it to meet new requirements. The worksheets were useful for the initial iteration of concept development as they assisted in documenting the logical flow of planning. They were designed to be modified with future iterations as additional information will be required as tasks become more discrete related to given scenario(s).

G. REVIEW AND FEEDBACK PROCESS

The review and feedback process was important to scope the Concept of Operations to something manageable for thesis-level work. This process had two distinct categories: internal and external. The internal reviews were conducted by the authors and the thesis advisors. These occurred on a monthly basis since the origin of this thesis in January 2014 and were broad in scope. The purpose of these reviews was for the authors to provide their points of view based on research and seek validation and determine if effort should be put forth for further research in a specific area. These sessions also allowed the advisors to inform the authors of complementary efforts of research which aided in scoping the thesis appropriately.

The external review process occurred twice and was attended by outside parties. The purpose of these reviews was to get a different perspective from a group of duty experts in their respective fields. These sessions were invaluable as it allowed the authors to gain a better understanding of complementary efforts within DOD and academia while connecting human-robotic control and collaboration opportunities and challenges. During an external review in July 2014, the authors concluded that the initial development of UTACC should focus on decision support employed to accomplish the mission with reduced human direction. Incorporation of robotic components to execute the mission is an important effort and required for UTACC to exist. The logic and associated software needs to be developed first for interoperability within the SoS.

The July 2014 review highlighted that this is an exciting and relevant body of work and the Marine Corps needs aggressive thinkers who can keep an exploratory focus on the future of combat systems. This review process also solidified the idea that UTACC software should complete 80% of the planning and allow the humans to refine the last 20%. This led to one of the largest challenges of UTACC which is dynamic semantic reasoning. Adding to this complexity is the reality that UTACC is initially being envisioned to enhance the capability of small tactical units in which Marines are required to be combat effective and not focused on operating robotic system(s); Marines carry rifles, not controllers.

Regarding programmatic efforts, this first external review led to two key considerations. The first was to start the project small and invest efforts to develop a strong conceptual core. If this was done correctly, future research can expand the breadth and depth of the initial efforts. Secondly, the scope of the mission should start from a blank slate and progress to target designation, the point where lethality can be applied. This allowed the Concept of Operations to nest neatly within the Intelligence and Command and Control Warfighting Functions.

The second external review occurred in August 2014 and had a more technical flavor. The authors learned that much of the technology exists to support the UTACC vision. However, the challenge is fusing the multiple independent sources with a shared common context. The Multi Agency Collaboration Environment (MACE) is a fusion center whose mission is "to protect the nation by leveraging the power of information to achieve cross agency interoperability, collaboration and shared awareness" (MACE, n.d., background/mission). During this review MACE personnel highlighted previous DOD successes and applicability. Another key theme from this external review was the incorporation of several feedback loops within the data flow diagram. These feedback loops will assist in identifying exception conditions and also add rigor to the automated planning framework. This second external review concluded with an in progress review hosted by MCWL and initial discussion for a Proof of Concept demonstration planned for early 2015.

The Proof of Concept demonstration, hosted by Carnegie Mellon University (CMU) in February 2015, was intended to prove that technology currently exists that allows UAVs and UGVs to collaborate for mapping a room and finding a target. The demonstration was successful. With the proper interoperable software developed for the demonstration by CMU and MACE, an UAV and UGV collaborated in a variety of scenarios to find a target (a green marker on a clipboard), take a picture of the target, and send that picture to higher headquarters without human assistance. Human input was only required to initiate the mission and confirm the positive identification of the target object. While this demonstration occurred in a controlled environment with CMU equipment, the results justify that UTACC is a viable concept with the capability to mature with advances in technology.

The success of the February 2015 demonstration and all the UTACC related exploratory research efforts since January 2014 gained the attention of The Honorable Ray Mabus (Secretary of the Navy) and Brigadier General Kevin J. Killea (Commanding General of MCWL). During the 2015 Sea-Air-Space Exposition, both leaders discussed UTACC's tactical value. Mabus' comments focused on innovation; he stated,

> With unmanned technology, removing a human from the machine can open up room to experiment with more risk, improve systems faster and get them to the fleet quicker. While unmanned technology itself is not new, the potential impact these systems will have on the way we operate is almost incalculable. For example, Lieutenant Rollie Wicks (another member of the UTACC initiative) developed a way for an unmanned ground vehicle to communicate seamlessly with an unmanned air vehicle, autonomously identify a target, and perform a mission. (Mabus, 2015, p. 7)

Killea's comments focused on the tactical value UTACC brings to the battlefield as the next level in battlefield autonomy (Tucker, 2015). Killea further explained, "The unmanned systems must recognize what they're being told to do, formulate a plan, and then execute a shared understanding of mission requirements…the Marine operator tells the unmanned systems what to do, not how to do it. This frees him up to work on other tasks while the autonomous systems collaborate together on tasks at hand to accomplish the mission" (Tucker, 2015, p. 1).

H. CHAPTER CONCLUSION

This research methodology combined systems engineering fundamentals with basic USMC troop-leading steps to design a Concept of Operations. While these disciplines are distinct from one another, fusion of the two disciplines created a sound research methodology. With regards to UTACC, these individual processes complement each other by integrating an expeditionary USMC culture with cutting edge tactics and technology. The SOW and initial guidance from MCWL provided the authors with enough information to create a Concept of Operations that remained exploratory in nature aligned with MCWL's mission. The fact that UTACC has gained the attention of The Secretary of the Navy and The Commanding General of MCWL further validates UTACC as a viable research area.

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IV. CONCEPT OF OPERATIONS

This section provides an executive level overview of the Unmanned Tactical Autonomous Control and Collaboration (UTACC) Concept of Operations. This executive level summary will focus on the major components of the Mission Planning and Execution Model (see Appendix B) which is supported by Information Exchange Requirements (IERs, see Appendix C) and 38 Task Analysis Worksheets (see Appendix D). To efficiently illustrate the Concept of Operations, a description of the Mission Planning and Execution Model will be amplified by a basic tactical scenario.

A. MISSION PLANNING AND EXECUTION MODEL

The Mission Planning and Execution Model was designed by combining the Systems Engineering Process and Troop-leading Steps discussed in Chapter III. Each element of the Troop-leading Steps was segmented into a swimlane to illustrate the sequential nature of mission planning. A feedback mechanism is explicit to demonstrate the critical nature of feedback between the swimlanes. The feedback concept is required to maximize automation of Intelligence Preparation of the Battlefield/Battlespace (IPB) by processing sensor inputs instantaneously to update a live map. Feedback is also critical for aspects of the Marine Corps Planning Process (MCPP) and small unit tactical planning because the humans and machines can collaborate as teammates to make planning adjustments before execution. During execution, the dynamic nature of operations requires constant feedback between all UTACC components to accomplish the mission by maximizing use of resources. Without feedback, the planning model is static based on potentially obsolete information and the execution will suffer due to the potential to mismanage all available resources.

The Mission Planning and Execution Model is populated with tasks and subprocesses. A subprocess is a grouping of tasks with a common purpose that is required within the larger Mission Planning and Execution Model. Each task has an associated Task Analysis Worksheet in Appendix D. The catalog number for that task is found in parenthesis under the task or subprocess name. Subprocesses denoted with

"Future Research" are not included within the Task Analysis Worksheets in Appendix D. However, they are described in Chapter V.

B. TACTICAL SCENARIO AND CONCEPT OF OPERATIONS APPLICATION

A very simplistic tactical scenario is required to illustrate UTACC's potential and further comprehend the application of the Mission Planning and Execution Model. The authors purposely kept the scenario simplistic in order to keep the focus of this chapter at an executive level and allow for creativity with potential UTACC capabilities during exploratory research. The scenario is based around the insertion of a small tactical unit with a UTACC system of systems (SoS) into their Area of Operations (AO). Their mission is for a human team member to locate and visually positively identify a Person of Interest (POI). They are provided basic information from higher headquarters: photos of the POI for visual identification, intelligence that the POI drives a 2000 White Toyota Tacoma, and the POI was last reported to be in a village within their AO 48 hours ago. The small tactical unit will be extracted after 96 hours if unable to locate the POI. If the POI is positively identified, then the small tactical unit will await further instructions from higher headquarters.

For this scenario, refer to Chapter II.C for definitions of: Small Tactical Unit, UTACC, Human Component, User Interface System (UIS), Air Carrier (AC), Unmanned Air Vehicle (UAV), Ground Carrier (GC), Unmanned Ground Vehicle (UGV), Cue, and Alert. The Air Component is comprised of one AC with at least two UAVs. The Ground Component is comprised of one GC with at least two UGVs.

1. Begin Planning

The mission planning begins with initialization of the system and the entry of mission parameters as depicted in Figure 6.

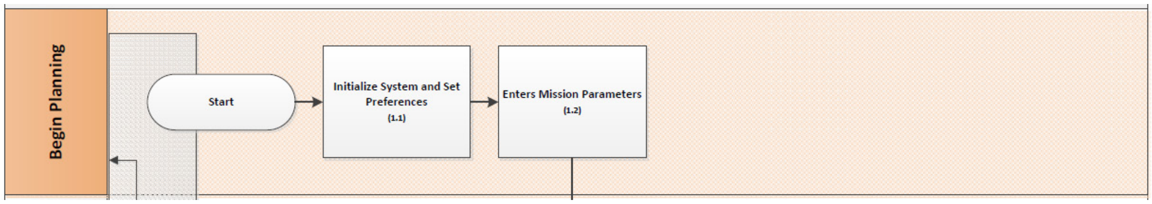

Figure 6. Begin Planning Swimlane

Scenario Application

(1) The Human Component enters mission inputs into the UIS to include preferences for a User Defined Operational Picture (UDOP).

(2) The Air Component is awaiting mission inputs.

(3) The Ground Component is awaiting mission inputs.

2. Arrange for Reconnaissance and Coordination

This unit must organically map their AO because of inaccurate map data. This will provide a basic orientation that will be further refined by selecting emphasis areas for more detailed mapping (see Figure 7). Sensors will be required to obtain Digital Terrain Elevation Data (DTED) and distinguish between types of terrain in order to build the foundation of information required to generate a Modified Combined Obstacle Overlay (MCOO; e.g., surface drainage effects, vegetation effects).

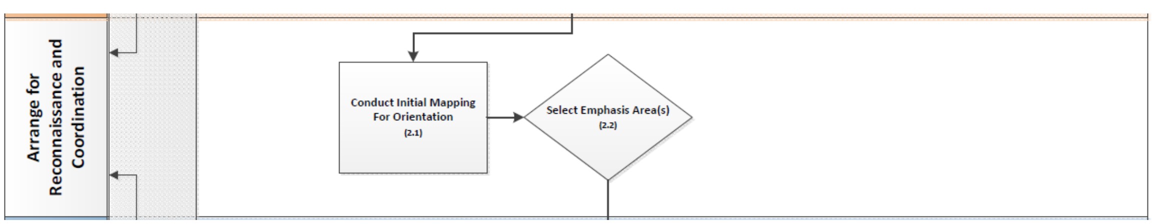

Figure 7. Arrange for Reconnaissance and Coordination Swimlane

Scenario Application

(1) The Human Component has already entered the mission inputs during the begin planning phase and can focus on other mission essential tasks until the initial mapping is complete. The Once alerted that the initial mapping

is complete, the Human Component can select emphasis areas via the UIS. For this scenario, emphasis areas are three villages, the routes leading to the villages, and an open field which can be a potential landing zone or danger area as shown in Figure 8.

(2) The Air Component executes a collaborative plan built by UTACC software to map the AO efficiently while minimizing overlap between sensors. This plan uses the principle of dynamic resource allocation meaning that UTACC decides how to best employ the assets. An example of dynamic resource allocation is one UAV refueling preemptively in order to ensure that all UAVs will not need to return for refueling simultaneously.

(3) The Ground Component executes a collaborative plan built by UTACC software to map the immediate area of the small tactical unit. This can potentially serve as a force protection measure if Ground Component assets/sensors are placed on likely avenues of approach to augment the small tactical unit's local security plan.

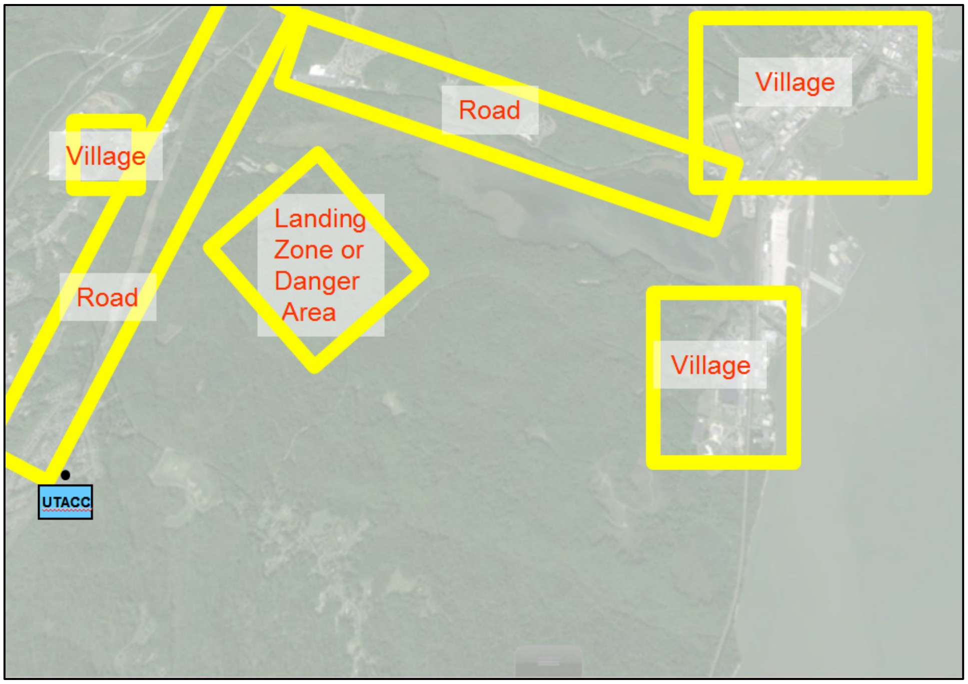

Figure 8. Initial Map with Emphasis Areas Selected (after Google Earth, 2015)

3. Make Reconnaissance

UTACC uses dynamic resource allocation between all available sensors to gain the mapping data required to build the MCOO as depicted in Figure 9. If the data is insufficient, the UIS will provide feedback (via cue or alert) to the small tactical unit. The MCOO process can begin once enough data is collected within an individual emphasis area. This simultaneous process saves time since all mapping data across the AO does not need to be complete prior to starting the MCOO.

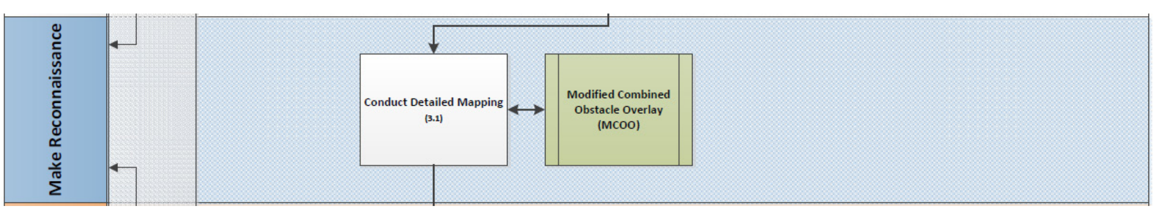

Figure 9. Make Reconnaissance Swimlane

Scenario Application

(1) The Human Component continues to focus on other mission essential tasks until the detailed mapping is complete. For this scenario, the UIS alerts the Human Component that one of the UAVs located a 2000 White Toyota Tacoma in one of the three villages.

(2) The Air Component continues to employ dynamic resource allocation to gain the detailed mapping required for the mission based off of the emphasis areas from the previous step (see Figure 10). For this scenario, one of the UAVs located a 2000 White Toyota Tacoma and alerts the Human Component. Based on initialization parameters, UTACC updates the dynamic resource allocation to maintain one UAV with coverage in vicinity of the 2000 White Toyota Tacoma as it is an indicator that the POI may be located nearby. Additionally, the dynamic resource allocation cues the Human Component that it is diverting a UAV with biometric capabilities to gain a possible biometric match. When the match is achieved, the Human Component is alerted. The Human Component designates the village Objective A as shown in Figure 11.

(3) The Ground Component continues to map the immediate area of the small tactical unit and augment the local security plan. The ground component can also conduct detailed mapping of emphasis areas if required in the immediate proximity of the small tactical unit.

Figure 10. Map with Detailed Mapping in Emphasis Areas (after Google Earth, 2015)

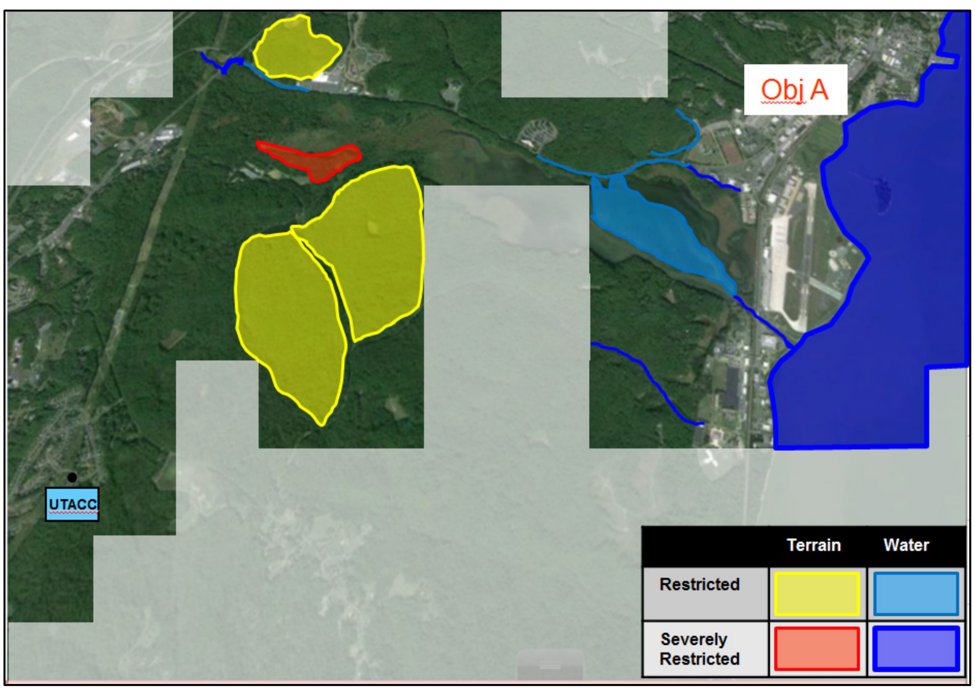

Figure 11. Map with MCOO and Objective A Annotated (after Google Earth, 2015)

4. Complete Plan

With enough information to develop a mission, UTACC software generates multiple mission profiles. Profiles may be refined multiple times via collaboration between the Human Component and the UIS. Figure 12 depicts the Complete Plan Swimlane and highlights UTACC utility as an automated planning tool.

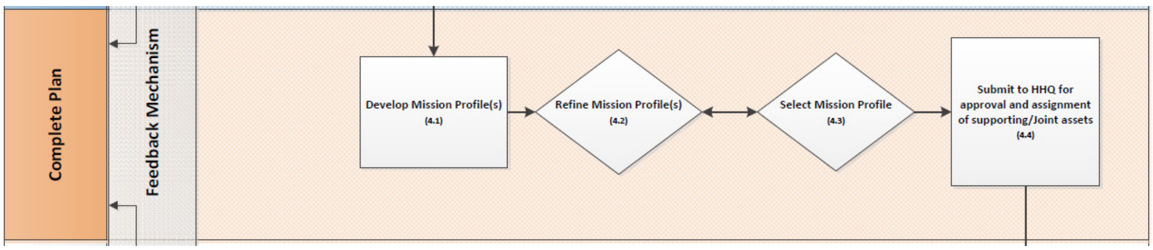

Figure 12. Complete Plan Swimlane

Scenario Application

(1) The Human Component, via the UIS, refines and selects the desired mission profile to move to a concealed position near Objective A in order to positively identify the POI.

(2) The Air Component maintains coverage of the POI and will transmit a live feed to the UIS for view by the Human Component if requested. Other UAVs are conducting reconnaissance of three potential route(s) to Objective A and will cue/alert the human component as required. For example, if one of the potential routes does not have sufficient map data for the system to develop a feasible mission profile, the system cues the Human Component that additional time and resources will be required to complete this profile.

(3) The Ground Component continues to augment the local security plan and initiates reconnaissance missions on the proposed route(s) to Objective A.

5. Issue Order

With the mission profile selected, the small tactical unit can issue the order and conduct digital 3D rehearsals as a unit or as a team (see Figure 13). A risk with automating mission planning is a reduction in the tacit knowledge gained by the human when going through the planning steps. Digital 3D rehearsals mitigate this risk.

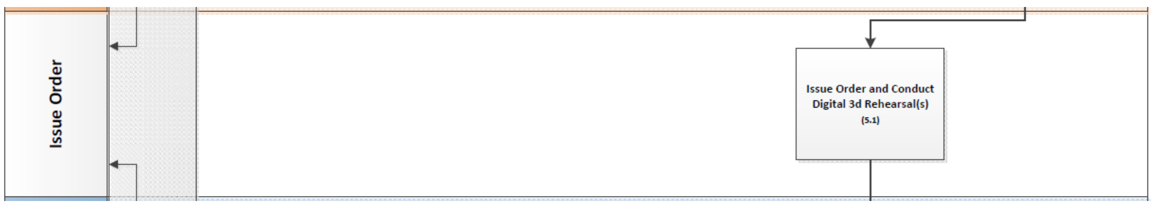

Figure 13. Issue Order Swimlane

Scenario Application

(1) The Human Component conducts digital 3D rehearsals, and is cued and alerted to issues that may affect the selected mission profile.

(2) The Air Component maintains coverage of the POI and will transmit a live feed to the UIS for view by the Human Component if requested. Other UAVs are conducting reconnaissance supporting the selected mission profile, and will cue/alert the human component as required.

(3) The Ground Component continues to augment the local security plan and initiates reconnaissance missions supporting the selected mission profile.

6. Supervise Activities

Previous to this step, UTACC functioned to automate planning efforts to the maximum extent possible. The actual execution of the mission is far more complex due to the number of variables. Figure 14 depicts some of the initial variables centered around the Task Module: Formations, Sensor Posture, Maintaining a Common Operational Picture (COP), Maintenance Alerts, and Tactical Alerts and Cueing.

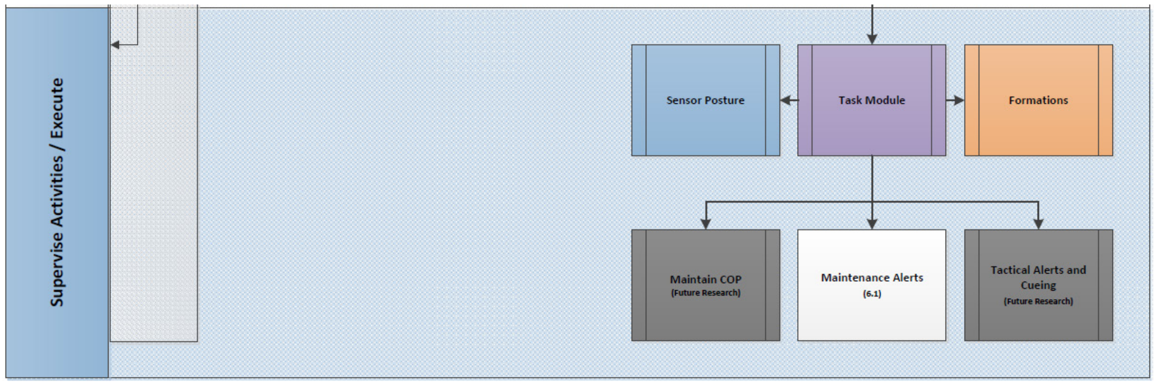

Figure 14. Supervise Activities/Execute Swimlane

Scenario Application

The small tactical unit moves to Objective A using all available resources to augment the mission. The dynamic nature of any mission will require constant collaboration between all UTACC components across the warfighting functions.

C. CHAPTER CONCLUSION

This section provided an executive level summary UTACC Concept of Operations. While this was limited in detail and specific tactical examples were omitted, UTACC's potential to support planning and execution is clear. The key aspect to the Concept of Operations is to maximize automation which allows the human to focus on other tasks that require critical thinking and/or mission preparation. UTACC's scalable framework can be built upon to include recommendations for further research discussed in Chapter V.

V. SUMMARY OF RESULTS AND RECOMMENDATIONS FOR FURTHER RESEARCH

As discussed in the introduction, this thesis had three distinct impact areas. The first area was to assist in the development of the 2014 Statement of Work (SOW) found in Appendix A. Second, the authors described a future Unmanned Tactical Autonomous Control and Collaboration (UTACC) vision as a starting point for long-term complementary research efforts. Finally, the authors created reference documents for system modelers to use during near-term prototyping. This combination of short/medium/long term viewpoints during exploratory research led to numerous findings which are outlined in this chapter.

A. SUMMARY OF RESULTS

The authors' preliminary summary of results has been incorporated in the 2014 SOW. General and complementary comments are below.

1. General Comments

The interdisciplinary body of work for UTACC truly integrates aspects of collaborative autonomy, human robotic integration (HRI)/human systems integration (HSI), decision support, and doctrine. The breadth of topics will likely expand as UTACC evolves because of its complex and complicated nature.

The early stages of UTACC can be designed solely as a planning tool under the condition that sufficient mapping and sensor data is available. The planning aspects of the Concept of Operations is aimed at automating the Intelligence Preparation of the Battlefield/Battlespace (IPB), aspects of the Marine Corps Planning Process (MCPP), and small unit tactical planning to the maximum extent possible so the human component can focus on critical thinking tasks and/or prepare for the upcoming mission. Despite the emphasis on automation, the authors are cognizant that human input and supervision is required at specific key points of the planning process.

Traditionally, IPB and MCPP are conducted by a staff; UTACC has the potential to serve as a proxy for specific staff planning functions. UTACC system capabilities can also expand to integrate non-organic aerial and ground components as well as fusing Common Operational Picture (COP)/Common Tactical Picture (CTP) feeds to maximize the human and machine understanding of the operational environment. These capabilities bring staff planning functions to the small tactical unit.

A risk with automating mission planning is a reduction in the tacit knowledge gained by the human when going through the planning steps. Mitigation for this knowledge gap would be a 3D virtual terrain walkthrough with the ability to conduct both individual and/or small tactical unit virtual rehearsals. While this sounds technically challenging, it is anticipated that the data necessary to accomplish this will already have been captured by UTACC sensors.

One of the advantages of UTACC being software based is the ability to maintain a data archive of previous missions for After Action Reviews (AARs). Another advantage is the ability to create a duplicate system with identical user preferences and export the organic information repository for use with a new system. This ability to duplicate systems has the potential to network various UTACC systems together under the cognizance of a small group of operators, with a shared mental model, who can provide mutual support to each other.

By virtue of maximizing automation, and given integration of external sensors, or additional organic sensor capacity, UTACC enables planning for subsequent mission(s) to occur during current mission execution. This is a significant shift from current practice because a human would be unable to execute small unit tactics and plan for follow-on operations simultaneously.

While the authors explained the logic behind the Concept of Operations from a doctrinal perspective; subject matter experts (SMEs) will be required to articulate nuances of the proposed framework as this initiative develops. SMEs within intelligence and reconnaissance are best suited for the first evolution of detailed analysis.

UTACC design needs to be incrementally focused on attainable goals with current technology. In 2015, the U.S. Army's Deputy Commanding General/Futures Director of the Army Capabilities Integration Center, Lieutenant General H.R. McMaster Jr., stated, "the biggest risk that we have today is the development of concepts that are inconsistent with the enduring nature of war" (Cox, 2015, p. 1). He continued, "the service must focus on accelerating the innovation of *attainable technologie*s instead of risking it all on leap-ahead capabilities that rarely make it to the battlefield" (Cox, p. 1). Despite being a U.S. Army perspective, the authors believe these are salient points for the UTACC initiative.

2. Complementary Efforts

Much of the technology exists to support the UTACC Concept of Operations. However, these technologies still require time to mature within their specific domain to the level envisioned in UTACC Concept of Operations. In addition, fusing the multiple independent sources with a shared common context will pose another technological challenge. Despite the maturity and fusion issues, initiatives should begin immediately to understand the problem set with current technology and evolve to incorporate future technology.

UTACC designers must leverage the effort put forth from the Marine Corps Intelligence, Surveillance, and Reconnaissance Enterprise (MCISRE). "MCISRE integrates disparate intelligence capabilities into a mutually reinforcing whole, generating always-on global situational awareness for the global crisis response force, supporting Marines and MAGTFs from mission initiation to mission completion, and providing situational awareness at the point of decision in order to place Marines in a continuous position of advantage on the modern battlefield" (USMC, 2014b, p 14).

UTACC designers must leverage effort put forth from the Defense Advanced Research Projects Agency's (DARPA's) Squad X project. The overview of Squad X is to address how to best equip small tactical units with integrated situational awareness to achieve a tactical advantage. "Squad X seeks to provide dismounted infantry squads with the capability to maneuver in distributed formations, while maintaining the capability to fight concentrated and mass effects. Squad X will focus on filling the following information gaps for currently equipped infantry squads: integrated access and control of mobile sensors (to include full motion streaming video); a three-dimensional common operating picture; near real-time friendly locations; and near real-time threat locations. Squad X seeks to build an integrated system of systems to organically extend the squad's awareness and influence. This topic will study the infrastructure and technologies necessary to build the Squad X system of systems" (DARPA, 2014, p. 2).

UTACC designers must investigate the U.S. Army's Future Combat Systems (FCS) initiative and understand why the program failed. While not identical in scope and intent, FCS lessons learned can bring out key friction areas that are relevant to UTACC's development.

B. RECOMMENDATIONS FOR FUTURE RESEARCH

UTACC, as a long term initiative, brings to light that there are a variety of areas that require further research in order to better educate stakeholders and inform warfighters, system designers, and system developers. This wide range of topics was expected due to the interdisciplinary exploratory nature of this research.

1. Scalability

UTACC is envisioned as a modular system of systems (SoS). This modular design allows UTACC to be scalable in nature to evolve to incorporate additional missions, conditions, and threats.

a. Missions

This thesis utilized a basic reconnaissance based mission as a vehicle to explain the UTACC Concept of Operations at the small tactical unit level. However, it is conceivable that UTACC can evolve to more complex missions as UTACC related capabilities mature. Keeping in line with the Marine Corps strategy as outlined in *Expeditionary force 21* (EF21), future research should investigate the role of UTACC in the 13 future Marine Corps focus areas. The authors chose two areas that pose the most interesting set of challenges: Naval Integration and Security Cooperation. The following ten focus areas will likely overlap efforts within Naval Integration and Security

Cooperation: Maneuver; Fires; Command and Control (C2)/NET Centric; Cyberspace and the Electromagnetic Spectrum; Force Protection; Intelligence; Expeditionary Logistics; Expeditionary Operations; Seabasing; and Marine Air Ground Task Force – Special Operations Forces Integration. The remaining focus area of High Quality People is not relevant as a UTACC capability because it is not tactical in nature.

(1) Naval Integration

The topic of Naval Integration is broad and a key assumption for future sea-based operations is the requirement to operate for extended periods of time, independently, and in a distributed fashion (USMC, 2014a). "Naval power projection capabilities underpin a broad spectrum of missions by allowing us to rapidly insert, support, and when appropriate, withdraw forces ashore; provide sea-based intelligence, surveillance and reconnaissance (ISR) and fire support to forces ashore; conduct riverine operations; and establish lodgments to facilitate the introduction of additional forces" (USMC, 2014a, p. 30). EF21 stated that a Fires capability consideration is to increase the "capacity to employ unmanned aerial systems from naval platforms and connectors supporting timely target acquisition" (USMC, 2014a, p. 34). It is clear that UTACC can enhance sea-based ISR, however, a fully developed UTACC can transform the methods to insert, support, and withdraw forces ashore through autonomous surface connectors. The next generation of surface connectors requires greater capacity, increased range, increased speed, reduced signature, and modular capabilities (USMC, 2014a). The authors recommend further research to develop a Concept of Operations for autonomous amphibious capability sets focused on connector employment.

(2) Security Cooperation

The topic of Security Cooperation is as broad as Naval Integration. "The Marine Corps conducts security cooperation activities to build the capacity of partner nations' security forces; build/establish relationships; and facilitate or provide access" (USMC, 2014a, p. 31). Nested within that vision are disaster relief operations. EF21 stated that there will be a "continuation of the recent trend towards applying military capabilities for humanitarian assistance and disaster relief" (USMC, 2014a, p. 9). Disaster relief operations are a low-end crisis response scenarios with strategic implications and involvement from other governmental agencies and non-governmental agencies (USMC, 2014a). UTACC's emphasis on ISR is ideal for disaster relief operations to gain valuable intelligence on the ever changing operational environment. One prominent UTACC constraint was the requirement for organic mapping and obstacle identification; this is extremely relevant in disaster relief operations as no existing maps will be able to accurately depict the current state of the terrain. The decision support aspect of UTACC would need to be adjusted for disaster relief operations in order to consider infrastructure considerations such as: "food, water, clothing, medicines, beds, bedding, and temporary shelter; the furnishing of medical equipment, medical and technical personnel; and making repairs to essential services, water points, food distribution centers" (DOD, 2010, p. 93). In essence, the tactical nature of UTACC as designed in this Concept of Operations would be replaced with a more logistically oriented planning toolkit. This highlights one value of UTACC's modularity; a common Orientation/Planning Module can be modified to support any mission given the proper planning framework. The authors recommend further research to develop a Concept of Operations regarding modifying the decision support aspect of UTACC to support disaster relief operations.

b. Conditions

Conditions document the variables of the environment that are relevant and affect specific task performance (USMC, 2015b). A key consideration is, "conditions are applied to specific tasks and not overall missions because conditions may affect tasks differently within the context of a mission" (USMC, 2015b, p. 4-3). This Concept of Operations was developed with minimal conditions. While this proved beneficial to scoping the project under a technology agnostic theme, it did neglect the reality of the operational environment with regards to conditions. As UTACC technology is implemented, the condition sets found in task analysis worksheets will require modification to accurately depict the impact that conditions have on the each component within the SoS. A comprehensive listing of conditions is found in Section 4, Conditions for Joint and Marine Corps Tasks of the Marine Corps Task List 2.0. As UTACC matures, the authors recommend further analysis into the role of conditions as related to individual UTACC tasks.

c. Threats

Similar to conditions, this Concept of Operations assumed a permissive environment. While beneficial to Concept of Operations development, the lack of threat cannot be assumed away with a mature UTACC. A robust threat module must be developed with associated immediate action drills, cues, and alerts. This effort will be complicated by the infinite amount of threats and variables associated with state and non-state actors. As UTACC advances, the authors recommend further research into building threat module(s) as a fundamental part of the UTACC planning modules. This effort will assist in wargaming scenarios to build a more comprehensive plan and will also assist in individual or unit rehearsals prior to the mission.

2. Capability Gap Metrics

There is a requirement to identify what capability gaps exist with regards to employing robotics in small tactical units. There is little gain to continue exploratory research or investment if there is no foreseeable tangible benefit for UTACC, especially in a highly contested fiscal Department of Defense environment. As UTACC research expands, a complementary effort must take place to compare how small tactical units conduct similar missions with current manning, training, and equipment sets. That baseline can be compared to UTACC's employment within the same scenario to determine areas that require improvement. Current metrics for non-UTACC tactical missions are found in *Marine Corps task list 2.0* and commonly include data that can be quantified (e.g., instances, percentages, times, durations). There are also Yes/No evaluations that are subject to interpretation by the unit commander. For example, Figure 15 depicts the definition and eight metrics associated with Marine Corps Task 2.7 Conduct Ground Reconnaissance and Surveillance.

MCT 2.7 Conduct Ground Reconnaissance and Surveillance
The ground combat element (GCE) Commander bases his reconnaissance and surveillance (R&S) on the intelligence preparation of the battlespace (IPB) plan. Marine Corps Reconnaissance units have the primary function of collection within the MAGTF Area of Operations and Area of Influence and may be tasked to conduct and perform area or zone reconnaissance, amphibious reconnaissance, and surveillance, employing assets to obtain, by various detection methods, information about the current activities of an enemy or potential enemy, or tactical area of operations. Tasks include conducting surveillance to systematically observe the area of operations by visual, aural, electronic, photographic, or other means, and to conduct specialized ground (dismounted/mounted) and amphibious reconnaissance. When properly task organized with other forces, equipment or personnel, Reconnaissance units can conduct specialized engineer, radio, mobile, and other unique reconnaissance missions. **(JP 2-0, 3-0, MCDP 2, MCWP 2-1, 3-1, 3-14.1A, NDP 2, NWP 2-01)**

M1	Percent	Of qualified and deployable MOS Marines available to conduct reconnaissance and surveillance operations.
M2	Percent	Of equipment ready and available to provide reconnaissance and surveillance operations (i.e., communications, target designation, crew served weapons, infiltration/exfiltration equipment, mobility assets).
M3	Y/N	Capable of conducting ground reconnaissance and surveillance across the MAGTF Commander's area of influence.
M4	Hours	From receipt of tasking, unit reconnaissance/surveillance assets in place.
M5	Percent	Of collection requirements fulfilled by reconnaissance/surveillance assets.
M6	Percent	Of time able to respond to collection requirements.
M7	Hours	To respond to emergent tasking.
M8	Hours	Of sustained reconnaissance and surveillance operations.

Figure 15. Marine Corps Task 2.7 Conduct Ground Reconnaissance and Surveillance (from USMC, 2015b, p. 154)

The authors recommend further analysis on the metrics of potential UTACC mission set(s) to identify capability gaps. This should include a series of evaluations with non-UTACC units and UTACC units completing the same mission(s) and comparing the results. This series of evaluations may lead to the creation of additional metrics assessing human machine collaboration, or new UTACC related tasks for inclusion in the **Marine Corps Task List 2.0**.

3. Security

"UTACC is a ground-breaking and original approach to using systems autonomy to augment and improve the ISR process. However, UTACC will fail to accomplish that task if the system is not built with security in mind from the outset" (Batson & Wimmer, 2015, p. v). Batson and Wimmer looked at the possible vulnerabilities to UTACC information based on Confidentiality, Integrity, and Availability (CIA). This CIA triad was examined using the lenses of People, Operations, and Technology and how these vulnerabilities could impact the success of UTACC: further research should expand upon this initial work.

4. Common Operational Picture Management/Fusion

The addition of autonomous robotic systems and advanced sensors at the small tactical unit level introduces challenges regarding the management of the immense quantity of data generated by the UTACC system. A critical future research area for the UTACC concept is COP management and fusion. Robotic UTACC components will generate and have access to an amount of data which in its entirety would overload any human or team of humans. The robotic components require all of this fused data in order to make sense of the environment and perform basic movement and navigational tasks. This is not problematic for the robotic components because of processors which compute faster than the human brain. However, the small tactical unit can only comprehend a fraction of the sum of data generated by the robotic components. An important capability which requires further research is the ability for the UTACC system to identify data which a Marine needs to make a decision and data which should be excluded from the human COP because it is not relevant for the human decision maker.

Different consumers of the COP require different information. The Marine rifleman in contact with the enemy may only require the location of the enemy presented through some form of heads up display. At the same time the company commander watching the battle from inside a forward operating base requires much more information presented on a larger display because he requires a higher level of overall situational awareness. This example also presents the issues of big data management and information push verses information pull to/from the COP. In the previous scenario, the company commander has the luxury of the time to pull required information from UTACC which he finds relevant. The Marine in contact does not have time to pull or request information from the COP; this information must be pushed. The system must determine when to push information and when to wait for an operator query.

The COP display is another challenge which requires future work. Current COP displays range from huge projections on a wall in a Joint Operations Center (JOC), to a laptop, to an image inside the visor of a fighter pilot, providing situational awareness directly to the eye. Fusing data from multiple sensors with other data such as elevation, object recognition, biometrics, etc.; and presenting the information to a Marine who can quickly gleam situational awareness regarding the environment is critical and also challenging. The end user display, also known as the User Defined Operational Picture (UDOP), is the mechanism to filter information so the end user has pertinent information and is not overloaded with routine information that distraction from the mission. Air and sea COPs are relatively simple because objects in those domains are limited: detected objects are likely to be aircraft or ships respectively. The complex nature of land domain makes it difficult to fuse a COP, primarily because of the diversity of objects and terrain. Some key aspects of a future land COP display are: it should be intuitively understandable (such as a 3D image), real or near-real time, and simple so that the only information displayed is that which is relevant to the decision maker.

Finally, future research work should address the ultimate end-state which is a tactical COP which is embedded within the larger COP of the combined/joint force. This integration will doubtlessly be one of the most challenging aspects of future concepts such as UTACC. For example, U.S. Army units in Afghanistan have found success with inter-agency collaboration through the use of commercial off the shelf (COTS) technology such as Google Earth as the base map for their COPs (Satchell, Dormish, & Parker, n.d.).

The diversity of accepted types of data with COTS technology could be useful as a starting point for integrating COPs across the combined/joint force. Current approved Military Standards (MIL STDs) should be used as a foundation for interoperability and fusion research. These include but are not limited to MIL STD 6017C for Variable Message Format (VMF), MIL STD 6016D for Tactical Data Link-16, and MIL STD 3011B for Joint Range Extension Application Protocol (JREAP). Intelligence fusion is already a priority research for the Marine Corps as outlined in the MCISRE Plan 2015–2020. While MCISRE is an enterprise effort, the end results will assist the tactical units.

Thus, UTACC efforts within COP management/fusion should be nested within the MCISRE framework and leverage existing MIL STDs.

5. Training

As with any new technology, UTACC will impose a steep learning curve for both training and maintenance. Addressing the training implications early in UTACC development and design will assist with end user familiarity with the SoS during training and operations. As outlined in this Concept of Operations the small tactical unit is the intended end user for UTACC. It is possible that the level of technological advancement required for UTACC is more appropriate for only highly skilled operators vice the average Marine. Regardless of the intended end user, UTACC must document proposed doctrine; potential Tactics, Techniques, and Procedures (TTPs); and potential Training and Readiness (T&R) standards.

6. Maintenance

The maintenance task analysis worksheet found in Appendix D provides a brief description of the basic sub-component monitoring and reporting requirements regarding the system health of the robotic components of UTACC. However, there is much room for future work regarding maintenance functions for UTACC. While the task analysis worksheet addresses the monitoring function of maintenance, it does not address how the robots recover from a faulty situation, or are repaired. Perhaps there are certain faults which, when detected, can be fixed during execution autonomously by the UxSs. This *self-maintenance* could improve the robustness of UTACC and reduce instances of degraded operations.

Future work should also address the continuous requirement for preventative maintenance or routine tasks. Periodically cleaning, lubricating, and fueling is essential to maintaining peak performance of any type of vehicle. Since the main purpose of UTACC is to reduce the load on individual Marines, it will be imperative to automate routine tasks freeing Marines to focus on mission essential tasks.

Despite the potential for automating maintenance functions, there will inevitably be times when major components break and will require human intervention. Due to the highly expeditionary vision of UTACC, these repairs will likely need to be conducted by the small tactical unit. This presents the problem of sub-component simplicity. Military vehicles are generally designed so that when things break, repair is as simple as pulling out the bad part and replacing it with a new one. This plug and play concept will be even more important for UTACC because the Marines conducting the repairs are not mechanics. Future designs should take into consideration that just because a complex sub-component works, it might not be an acceptable solution if the sub-component is too complex to be repaired by the average Marine.

Each UTACC machine component in the SoS will also have software maintenance requirements. Advanced technology is required in order to achieve UTACC's goal of being a teammate with a specified degree of autonomy instead of a tele-operated tool. This will require additional and complex software which will require regular and emergent updates to mitigate vulnerabilities in the cyber world. The complexity of this software will preclude the small tactical team from being capable of maintaining this software; updates will need to be pushed to the machine components from the UTACC development team. The small unit team leader would receive an alert before a software update is installed to prevent negative impacts to ongoing missions.

7. Change to Air/Battlespace Management

The UTACC concept presents unique challenges regarding the future of Air (C2) for the Marine Aviation Combat Element (ACE). Marine Air C2 agencies such as the Tactical Air Command Center (TACC) and the Direct Air Support Center (DASC) use both positive and procedural control in order to de-conflict airspace in theater. The DASC utilizes procedural control at lower altitudes (the primary operating altitudes for UAVs), de-conflicting aircraft both vertically and laterally through voice communications with each individual aircraft commander. This system would not work in airspace cluttered with autonomous UAVs unless the DASC has the means to communicate with these vehicles. Future work should address how UTACC will fit into our current airspace structure. One possible solution is for the DASC to have routing authority of the UTACC UAVs which presents a host of authority and technology challenges. Another option is to make major changes to airspace management procedures.

Regardless of the type of control utilized by various C2 agencies, they all share one common end-state; de-confliction of aircraft. Concepts such as UTACC could push future research into completely re-engineering the way midair collisions are prevented in future combat zones. There is sure to be a period of time when autonomous UAVs are in their infancy and have not completely replaced manned flight; a key challenge will be controlling both manned and autonomous systems simultaneously in congested airspace. One possible solution is rather than finding ways to de-conflict airspace, researchers should find ways to *integrate* the airspace. If autonomous systems all share a common operational picture, the individual vehicles could de-conflict themselves, also known as self-synchronous de-confliction. There would be no need to move all aircraft out of a restricted operating zone to fire artillery if all of the aircraft know the exact trajectory of said artillery round. This method of airspace control could potentially not only solve the problem of de-confliction, but could also improve the speed and efficiency of air support. This idea is simple as long as all aircraft in theater are autonomous; the challenge for future researchers is determining a method of integrating airspace which consists of both manned and autonomous vehicles.

8. Robotics

UTACC's premise enables small tactical units to operate independent of external support to accomplish their mission; the design and role of the robotic components require more thorough investigation. For example UAVs will require greater payload capacity, increased loiter times, and decreased size. Similarly UGVs need to operate at high rates of speed on complex terrain. Further research into various robotic systems is required to fulfill the requirements of a mature UTACC system.

9. Biometric/Multi-sensor

The incorporation of biometric software is an important aspect of UTACC. Many of the missions that small tactical units are tasked with require high levels of fidelity to confirm the presence or identity of a person of interest. The integration of biometric systems that can collect this information from a distance will be a significant advantage to the small tactical unit allowing them to remain covert while accomplishing the high risk portions of their missions.

Similar to biometric software for personnel, a multi sensor suite with associated software should be capable of tracking objects of interest as they traverse the battlefield (e.g., radar physical characteristics/electronic signature, vehicle make/model, license plate).

10. Human Health Tracking

One area that could significantly assist the unit leader is in human health tracking of his team members. Providing the unit leader's with cues and alerts depending on the health of the members of their teams could greatly enhance the team leader's situational awareness when geographically separated from a portion of their team. This system could be similar to how National Aeronautics and Space Administration (NASA) tracks astronaut vital signs during missions. One example might be an alert to the unit leader that a unit member's blood pressure has fallen while their heart rate has spiked which could be a sign that the unit member has been injured and might require immediate medical attention. In another scenario during a long tactical movement, a cue might inform the unit leader that two of the unit members' body temperatures are elevated; the unit leader could then choose to either slow the rate of movement or order a halt. Small unit health tracking is a complementary research area that could be easily integrated into the UTACC framework.

11. User Interface System

One of the most important components of the UTACC system will be the user interface component. This will be a combination of systems that push and pull information between the human and machine components to plan, rehearse (e.g., 3D walkthrough), and execute a mission. To do this effectively the information presented to the human must be in a format that is easy for the human to cognize, and must be presented in a way that does not pull the humans attention away from their primary mission and thus endanger the human. A risk with a functional user interface is that the user becomes fixated on the display and fails to pay attention to their physical surroundings. For example, it is common to hear of smart phone users walking off steps, into walls, or out in front of traffic because they were too focused on their phone and not on their surroundings. If this user interface fixation were to occur with UTACC, the results could be deadly to the humans.

Presenting information to the human is only one part of the user interface. The robotic components also need to receive input from the humans. Searching through menus and typing into an interface could be detrimental to the operation of the human team. Ideally the robotic components would be able to receive the same inputs that are presented to the human members of the small tactical unit. To achieve this, UTACC components will need to be capable of natural language processing and be able to recognize hand and arm signals presented by any member of the small tactical unit. Further research needs to be focused on voice recognition software/natural language processing and human motion recognition.

12. Power/Energy Supply

The envisioned technological components of UTACC will require the system to have an abundant amount to power and energy to fit into the current operational scenarios. The system will need to have sufficient capability to operate for an extended period of time without support from an external agency. Since it is unfeasible for the smaller UAVs and UGVs to have this type of endurance the Air and Ground Carriers should be capable of refueling/recharging these smaller systems without the aid of a human. Another concern will be the stealth of the system so a quiet power source will be necessary. Future research should investigate fuel cells, renewable energy, or other advanced sources of power capable sustain the SoS.

C. CHAPTER CONCLUSION

UTACC is a valid exploratory research area that investigates the concept of collaborative autonomy between humans and machine components for the future Marine Corps. As discussed in Chapter I, this thesis is one of the first seeds to a potentially larger initiative at the enterprise level. The summary of results serves as a starting point for discussion about UTACC's tactical value. The extensive recommendations for further research illustrate the complicated and complex nature of collaborative autonomy. Despite the myriad of challenges with fielding a UTACC capability, stakeholders must always remember that UTACC is conceptualized around employing robotics to enable Marine units to be more combat effective.

APPENDIX A. STATEMENT OF WORK

SEE FOLLOWING PAGE

STATEMENT OF WORK FOR NAVAL POSTGRADUATE SCHOOL (NPS) CONCEPT OF OPERATIONS (CONOPS) DEVELOPMENT SUPPORT TO THE MARINE CORPS WARFIGHTING LABORATORY (MCWL) UNMANNED TACTICAL AUTONOMOUS CONTROL AND COLLABORATION (UTACC) PROJECT

1. BACKGROUND

The Marine Corps Warfighting Laboratory (MCWL) located in Quantico, Virginia, requires a multi-agent, multi-domain, collaborative Unmanned System (UxS), hereafter known as Unmanned Tactical Autonomous Control and Collaboration (UTACC). UTACC shall consist of both a ground component(s) and an aerial component(s) acting in a collaborative fashion as a single system with a single operator in order to evaluate Marine Corps Expeditionary Force 21 (EF-21) concepts.

UTACC, in its final configuration, is intended to be a decision-centric, semi-autonomous, distributive, multi-agent, multi-domain robotic system.

UTACC is a multi-year program starting in mid FY14. This SOW applies to FY14 activities.

1.1 UTACC Primary Objective

The main objective of UTACC is to develop a Systems of Systems (SoS) and architecture that will significantly minimize operator interaction over current systems and allow the system the flexibility required to react to a wide range of operational missions, environmental conditions, and landscapes as based on the immediate operational needs of the commander.

1.2 UTACC Expected Operations

Upon full effort completion (which is out of scope of this SOW), UTACC is as functioning as an Intelligence, Surveillance, and Reconnaissance (ISR) asset, although exact force structure integration will be dependent on the CONOPS and operational evaluation. It is highly likely to be deployed from a ship to a shore based objective alongside a Marine Recon squad. The method of deployment will be dictated by operational requirements during the mission. Deployment could be by air drop, helicopter, plane, amphibious landing, or “something else.”

1.3 Final System Required Capabilities

1. In order to properly evaluate the concept, the UTACC test article should consist of no less than three Unmanned Ground Vehicles (UGV)s and one Unmanned Air Vehicle (UAV) collaboratively working together to perform a common mission under the cognizance of a dismounted Marine in a dynamic, kinetic, and complex environment.

2. The system should be able to map an area, identify obstacles and traverse to objects of interest such as buildings or other object as dictated by the operator without previous information.

3. Distributive Architecture and Processing: The system should be designed with a distributed architecture so that the loss of one agent or the controller does not render the entire system non-functional.

4. Adaptive Behaviors Enabling Minimal Operator Workload. The system should allow the respective agents to work together collaboratively to position and overcome obstacles to mission accomplishment with minimal operator intervention.

5. Autonomous system diagnostic monitoring, (otherwise known as a health system) should occur at a sub-system level. This information should be made available to the operator at the level and scope that he requires, but more importantly, the health information should be made available to the system itself for use in monitoring the current (and in some cases, the historical) state of each agent and its associated resources.

6. The architectural infrastructure should be developed in such a way as to allow for modularity and easy integration of legacy and future systems.

7. Each entity shall contain a General Purpose Entity Processing Node (GEN) to enable collaborative operations as defined in Section 1.4. The GEN is an as yet identified reasoning agent embedded within each entity. This agent will provide platform situational awareness to other collaboration participants as well as reason and make decisions based on the situational awareness received from the other collaborators as well as its own. The GEN is the name given for the architectural component.

8. Easily maintained and serviced.

9. The system should have the ability to operate while utilizing the unmanned vehicle’s power, without adversely impacting the vehicle’s performance.

10. Environmental[1]
    a. Wind Speed: The system should be operationally functional at wind speeds at 15 knots minimum.

       Note: Not all agents need to meet the 15 knot threshold. For example, if quad copters are used, but they only have a threshold of 4 knots,

[1] The system is NOT expected to be MIL-STD-810G compliant nor will it be. MIL-STD-810G methods are provided only for clarity.

there must be another aerial agent that can operate up to 15 knots in the event it is a windy day. 20 knots is the advertised Raven threshold.

b. The system should function in heavy dusty or sandy environments. MIL-STD-810G method 510.6 can be used as a guide and definition for expected conditions.

c. Rain: The ground components should function in blowing rain. The aerial components should function in light rain or drip. MIL-STD-810G method 506.5 can be used as a guide or definition.

1.4 Terms of Reference

Term	Definition
Agent	An agent is defined as anything that can sense its external environment, and through its own means, interact with that environment. An agent can be virtual, such as a software process, or physical such as a robot, animal, plant, ship borne sensor, or even a human. Often, the term autonomous is used to refer to an agent whose decision making relies to a larger extent on its own perception than to prior knowledge given to it at design time. In UTACC, the human, the robots, and distinct software algorithms are all considered agents.
Collaboration	Entities working towards a common purpose. To succeed, they need a common plan, objectives, and mission knowledge. They must be able to share situational awareness to the maximum extent possible. Finally, each entity of the collaborative team must be able to adjust to changes in the environment, landscape, mission, and plan dynamically. See Reference 1 for complete definition.
Coordination	Entities working with similar but distinct purposes. There would be periodic but not dynamic exchange of these purposes across entities only to promote deconfliction. No assumption of shared situational awareness is given. See Reference 1 for complete definition.

Term	**Definition**
Data Exchange Requirements (DER)s	DERs refer to individual data elements that must pass amongst the system's sub-systems, inclusive of the human controller.
Distributive Architecture	In UTACC, distributive architecture describes the underlying architecture for the system agents specifically invoking concepts such as data centricity, distributed processing and distributed communications.
Entity	This is different from an agent such that it does not describe interactions, it simply describes a thing. As used in this effort, entity is intended to describe a singular unit or object, such as a robot or human. While this may also include a discrete software application, process, or algorithm, software is not included in this definition for the purposes of UTACC.
Heterogeneity	Generally speaking, it is defined as the quality of diverse and not comparable in kind. As specifically applied to UTACC, it is meant to define a capability of the system. That capability is the ability to mix and match platforms, payloads, and algorithms from various vendors that utilize various data formats or protocols, as applied to control systems, sensor information, or otherwise. It is expected that enablement of this capability will require a middleware
Human Machine Interactions (HMI)	A description and/or characterization of how a human interacts with a machine. HMI, in an operational context, defines the "style" and methods used to instruct machine systems and as such has a large impact on the overall C2 characteristics of such a system. HMI is a subset of IERs.
Information Exchange Requirements (IER)s	IERs refer to the information and C2 flow between the system and the human. Furthermore, IERs are intended to capture the best way possible, or HOW, a human interacts with the machine. Taken together, the IERs define the requirements for human-machine interactions.

Term	Definition
Machine Map	In UTACC the machine map is a 3-D, spatially accurate representation of the external environment collectively shared amongst the various robotic entities for navigation or position information, colloquially termed the "machine map" or "geometric map."
System State Map	In UTACC the system state map is the current state of the system which includes, but is not limited to, the position of each entity, system and sub-system health metrics, sensor statuses, software execution status, mobility considerations, etc.
World Map	In UTACC the world map consists of the System State Map, the Machine Map, and the World Model. The purpose of the World Map is to allow for the identification of self within the external environment which is required for effective automated planning.
World Model	An ontology that formally represents knowledge as a set of concepts within a domain, and the relationships between pairs of concepts. It is used to model a domain and support reasoning about entities or agents.

1.5 Assumptions

1. The complete UTACC system is defined to mean an armed Marine conducting operations with the assistance of collaborative semi-autonomous UGVs and UAVs. These three entity types are said to comprise one UTACC system.

2. UTACC is designed to be completely modular. In the long run this implies any set of UGS, UAS, and Marine, with any mission, terrain, and environmental combinations. The performer expects assistance from MCWL in defining the initial mission, terrain, and environment requirements.

3. All functionality is to be distributed, such that the loss of one entity does not limit the ability of the others to continue the mission.

4. MCWL will provide the robots, physical network components, and robot control systems, or make arrangements to such.

5. The performer assumes that robots have a control component, network/communications component, and sensor unit present. We assume that

UTACC robots will also require a GEN. While the performer can contribute to the design of the GEN unit, the performer expects support in developing this component.

6. While this document generically states "the Marine," this may imply some sort of control unit hardware associated with the Marine independent of the UGS and UAS.

2. SCOPE

This Statement of Work (SOW) establishes requirements for Concept of Operations (CONOPS) development for a collaborative robotic system and derivation of associated requirements as delineated in section 0 below.

3. GOVERNMENT TASKS

3.1 (FY14)

3.1.1 Develop a CONOPS from an operational perspective.

This will capture the operational activities and associated functions, and be detailed enough to derive all the potential Information Exchange Requirements (IER)s and applicable Data Exchange Requirements (DER)s. This CONOPS will be captured so that another party may use it to create an executable model using appropriate tools that enable reuse, parametric comparisons, extensibility, and technically integrate it into existing C2 planners.

3.1.2 Derive IERs from the CONOPS.

3.1.3 Derive DERs from the CONOPS where relevant.

3.1.4 Provide an initial mission assurance analysis based on the model described above.

3.1.5 Survey robot functional details with UTACC robotic partner SMEs as designated in this SOW under task 0 and reference 2.

3.1.6 Identify operational, technical, and other risks. Develop risk mitigations. (e.g., unsolved known's, who builds network, what about unknown unknowns, test instrumentation: should the robots and Marine be required to record all their actions?)

3.1.7 Prior to the end of the period of performance, conduct independent technical review with appropriately qualified practitioners.

3.1.8 The performer will partner with NASA to conduct a technical audit of the CONOPS, provide input and review to the modeling conducted by the full system integrators.

3.1.9 NPS shall be present at the four major technical interchange and effort review meetings currently planned. Those meetings consist of the kickoff meeting, the mid effort review meeting, the independent technical review, and the final FY14 effort closeout meeting where CONOPS findings and the associated requirements will be presented.

4. DELIVERABLES

4.1 FY14

1. Operationally focused UTACC CONOPS.
2. IERs as derived from the CONOPS.
3. Relevant DERs as derived from the CONOPS.
4. Initial Mission Assurance Analysis.
5. Risk management plan.
6. UTACC CONOPS briefing for MCWL.
7. UTACC initial mission assurance plan.
8. Technical review white paper.
9. Report of external technical audit of CONOPS.
10. NASA's input to full system integrators' model, which is specified in reference 2.

5. OTHER INFORMATION

MCWL will retain all rights to any intellectual property developed under this contract.

6. REFERENCES

(Note: References will be delivered electronically)

1. C2A2 The Link from Technical Instantiation to Operational Utility
2. AFRL SOW

7. NOTIFICATION OF SHIPPING

Any shipping under this effort will be handled by Naval Surface Warfare Center Dahlgren Division (NSWCDD), contact: Steve Praizner, 703–432-0465, steven.praizner@usmc.mil within 24 to 48 hours before delivery to inform the receiving agency of the estimated shipment arrival time and any tracking information available.

8. FREE ON BOARD (FOB) DESTINATION

Commander
Naval Surface Warfare Center Dahlgren Division
Attn: Steve Praizner (G82)
6096 Tisdale Road, Suite 307
Dahlgren, Virginia 22448

9. REQUIRED DELIVERY DATE: TBD

10. PERIOD OF PERFORMANCE

Overall efforts identified within this SOW are scheduled to begin upon funding acceptance and complete by 31 Dec 14.

11. PLACE OF PERFORMANCE

Performance of this SOW shall be at NPS and those places assigned by MCWL.

12. TRAVEL

Travel is anticipated in support of building the executable model with the modelers, face to face meetings with the robotic SMEs, face to face meetings to discuss the results of the mission assurance analysis, and several face to face meetings for the project team at NPS. Finally, one meeting is expected at Quantico with the sponsor. Video teleconferencing, proven in many research publications to be even less effective than plain old telephone systems, is not sufficient for the technical depth that must be explored to accomplish these challenging tasks.

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APPENDIX B. MISSION PLANNING AND EXECUTION MODEL

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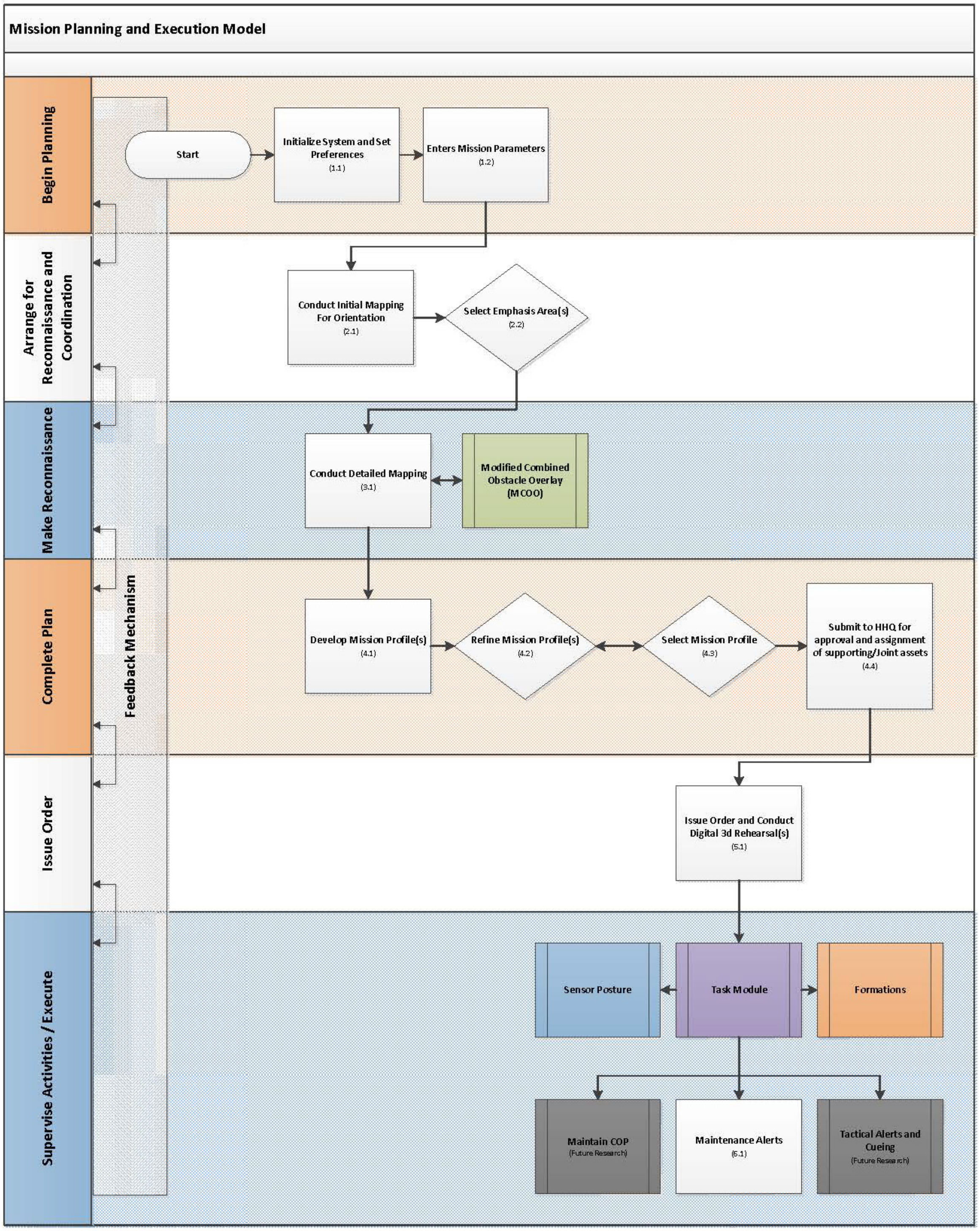
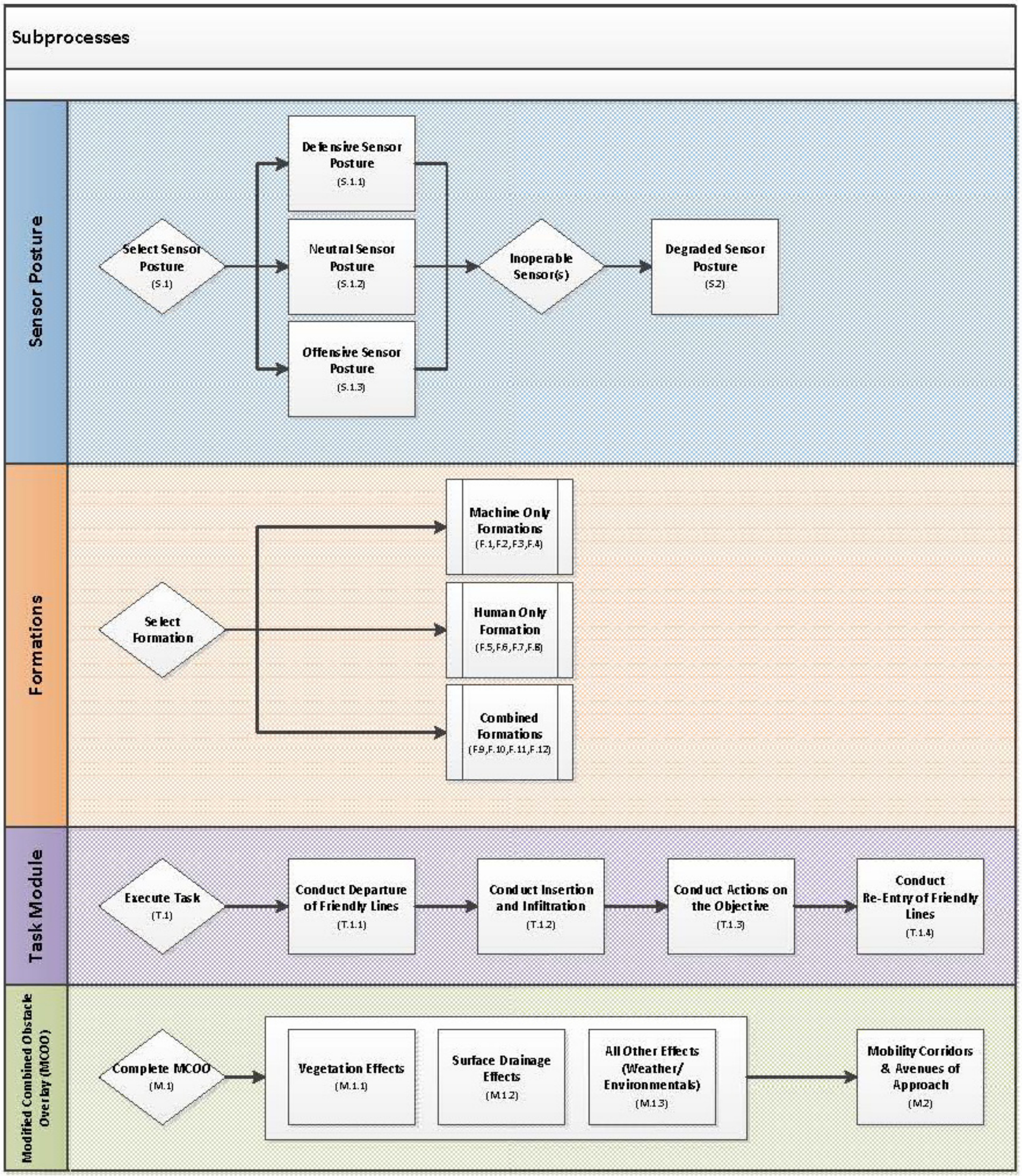

Mission Planning and Execution Model
Begin Planning
Arrange for Reconnaissance and Coordination
Make Reconnaissance
Complete Plan
Issue Order
Supervise Activities / Execute
Feedback Mechanism
Start
Initialize System and Set Preferences (1.1)
Enters Mission Parameters (1.2)
Conduct Initial Mapping For Orientation (2.1)
Select Emphasis Area(s) (2.2)
Conduct Detailed Mapping (3.1)
Modified Combined Obstacle Overlay (MCOO)
Develop Mission Profile(s) (4.1)
Refine Mission Profile(s) (4.2)
Select Mission Profile (4.3)
Submit to HHQ for approval and assignment of supporting/Joint assets (4.4)
Issue Order and Conduct Digital 3d Rehearsal(s) (5.1)
Sensor Posture
Task Module
Formations
Maintain COP (Future Research)
Maintenance Alerts (6.1)
Tactical Alerts and Cueing (Future Research)



Subprocesses
Sensor Posture
Select Sensor Posture (S.1)
Defensive Sensor Posture (S.1.1)
Neutral Sensor Posture (S.1.2)
Offensive Sensor Posture (S.1.3)
Inoperable Sensor(s)
Degraded Sensor Posture (S.2)
Formations
Select Formation
Machine Only Formations (F.1,F.2,F.3,F.4)
Human Only Formation (F.5,F.6,F.7,F.8)
Combined Formations (F.9,F.10,F.11,F.12)
Task Module
Execute Task (T.1)
Conduct Departure of Friendly Lines (T.1.1)
Conduct Insertion and Infiltration (T.1.2)
Conduct Actions on the Objective (T.1.3)
Conduct Re-Entry of Friendly Lines (T.1.4)
Modified Combined Obstacle Overlay (MCOO)
Complete MCOO (M.1)
Vegetation Effects (M.1.1)
Surface Drainage Effects (M.1.2)
All Other Effects (Weather/ Environmentals) (M.1.3)
Mobility Corridors & Avenues of Approach (M.2)

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APPENDIX C. INFORMATION EXCHANGE REQUIREMENTS

The Information Exchange Requirements (IER)s contained in this appendix were derived from a Marine Corps initiative to develop and validate the IERs for Company level and below elements within the Marine Air Ground Task Force (Shivers, 2012). This list is designed to be an initial compilation of IERs that are required to support the Unmanned Tactical Autonomous Control and Collaboration (UTACC) Concept of Operations outlined in this thesis. The authors anticipate addition to this list of IERs as the UTACC concept is further refined and expanded.

The authors categorized this initial set of IERs as either: System Baseline (SB), Blue Force (BF), Common Tactical Picture (CTP), System Updates (SU), or Reports (RP). It is important to identify that IERs may be applicable to more than one category. Equally important is the fact that IERs and can be referenced as the situation dictates. For example, SB IERs are applicable across the Planning and Execution Model especially if there is a change in the composition of the Small Tactical Unit. Another example is the requirement for the CTP IERs to continuously be updated which results in a near real time information displayed on the UTACC map.

A. SYSTEM BASELINE

KEY	Information Exchange	Content	Reference	Notes	Peridicoty	Size of File
IER-SB-01	Commander's Planning Guidance	The commander develops his initial guidance using his commander's battlespace area evaluation, his experience, and the mission information available from higher headquarters. The commander's initial guidance provides the staff and subordinate commanders with additional insight on how the commander views the mission. Depending on the time available, the commander may provide general guidance, contingency plans, and specific points he wants the staff and subordinate commanders to consider (a particular enemy capability, a certain task organization, etc.).	MCWP 5-1, JP 1-02	N/A	On Demand	100 Kb with out graphics
IER-SB-02	Commander's Critical Information Requirements (CCIR)	Information regarding the enemy and friendly activities and the environment identified by the commander as critical to maintaining situational awareness, planning future activities, and facilitating timely decision-making. CCIRs are normally divided into three primary subcategories: priority intelligence requirements; friendly force information requirements; and essential elements of friendly information.	MCRP 5-12C,	N/A	On Demand	20 Kb
IER-SB-03	Communications-Electronics Operating Instructions (CEOI)	A scheme or method for exchanging information between individuals by means of speaking, writing, a common system of signs or behavior, or transmissions. The message containing Challenge and Passwords, Call Signs and Countersigns	MCRP 5-12C	N/A	On Demand	1 Mb

IER-SB-04	Warning Order (WO)	A notification message identifying threat information, higher mission and intent, mission, intent, tasks, C2 and coordination information. The intent is to give unit leaders some information so they can do concurent planning while the full order is being developed.	MCWP 5-1 (Annex K)	N/A	On Demand	100 kb
IER-SB-05	5 Paragraph Order	Five paragraph field order - A directive issued by a commander to subordinate commanders, it contains as a minimum a description of the task organization, situation, mission, execution, administrative and logistics support, and command and signal for the specified operation. Orders in a tactical environment may be in a matrix or overlay format. The Orientation paragraph is routinely added to the front of the Five Paragraph Order.	JP 1-02, MCWP 5-1 (Annex K)	O- Orientation S- Situation M- Mission E- Execution A- Administration & Logistics C- Command and Signal	On Demand	100 Kb with out graphics
IER-SB-06	Biometrics Information	Information to include; fingerprints, iris scans, voice pattern and facial images. Submitted information can be used to find a “match” for personnel whose biometrics corresponds to a record in stored data. Passed as required.	JP 2-0	N/A	On Demand	>5 Mb per individual
IER-SB-07	High Value Individual (HVI) List	A report identifying High Value Individuals.	MCRP 2-3A	N/A	On Demand	100 Kb without graphics

IER-SB-08	Person of Interest (POI) List	A report identifying Persons of Interest.	MCRP 2-3A	N/A	On Demand	100 Kb without graphics
IER-SB-09	Intelligence Preparation of the Battlespace (IPB) Products	IPB is a systematic process of analyzing and visualizing the portions of the mission variables of adversary, terrain, weather, and civil considerations in a specific area of interest and for a specific mission. IPB products may include: enemy "order of battle" to include: composition, disposition, strength, tactics, training, logistics, combat effectiveness, electronic/technical data, C2W data, and miscellaneous data, key leaders, ideology, objectives, preferred environment and geography, internal support to insurgency, phase of insurgency and organizational and operational patterns.	JP 1-02, MCRP 2-3A	ASCOPE (Civil Considerations) is part of IPB step 2. The Marine Corps does not consider ASCOPE a report and there is no doctrinal format; however it provides detailed descriptive information on battlefield effects within one or more of the ASCOPE categories of: Area, Structure, Capabilities, Organization, People, Events.	On Demand	5 Mb w/ graphics
IER-SB-10	Geospatial Intelligence	GEOINT is a product of intelligence derived from using all-source geospatial and other intelligence information with regard to the military aspects of the terrain in support of MAGTF operations.	MCWP 2-26	GEOINT can include cross-country movement (CCM) studies, line of sight (LOS) analysis, natural and manmade obstacles, and various terrain studies (e.g., road, railroad, airfield, bridges, ports, helicopter landing zones).	On Demand	< 700Mb
IER-SB-11	Rules of Engagement (ROE)	All team members need be educated on ROEs. Every Marine down to the lowest levels should know how these regulations apply to their specific mission. Try to answer as many questionable “what if” scenarios beforehand with all platoon members to ensure equal understanding and compliance for actions/reactions that fall within the Battalion's intent and IO plan.		N/A	On Demand	100 Kb without graphics

B. BLUE FORCE

KEY	Information Exchange	Content	Reference	Notes	Peridicoty	Size of File
IER-BF-01	Human Health Report	Zephyr is a company which produced a monitoring system for under armor clothing to monitor pro athlete's vital signs. The "Zephyr BioHarness" is a narrow fabric band worn around the upper torso that is capable of providing physiological status monitoring for people in any condition or environment. NASA partnered with Zyphyr to implement the device in studies of motion sickness and tracking vital signs in strenuous conditions. The unit is about the size of a cell phone and can be woven in to the fabric of a uniform and can transmit vital signs into the enterprise engine. (In other words, this can be accomplished already with COTS technology)	NASA Website: http://www.nasa.gov/offices/oct/home/tech_life_zephyr_prt.htm	Unit ID heart rate heart rate variability electrocardiogram breathing rate skin temperature blood pressure	Data can either be stored or transmitted wirelessly when a vital sign threshold is exceeded	2 Kb
IER-BF-02	Equipment Status	UTACC components should periodically perform built-in-tests of critical sub-components (sensors, avionics, engine components, etc.). Sub-Components should be grouped based on how critical the component is in executing a task. These groups are labeled fully-mission capable (FMC), partially-mission capable (PMC) and non-mission capable (NMC).	COMNAVAIRFORINST 4790.2B, CH. 17 (Subsystem capability and impact reporting) via Maintenance Alert Task Analysis Worksheet	See "Maintenance Alerts" Task Analysis Worksheet	System does not broadcast unless change in status. NMC= ALERT PMC= CUE FMC= RECORD FOR LATER (On Demand)	2 Kb

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IER-BF-03	Participant Location and Identification (PLI)	A report transmitted every 5 -30 seconds identifying an agent of a participant (human or machine component) and providing their location. More information can be transmitted in this report, such as weapons loadout, battery life, or fuel as required. The more frequently these messages are transmitted, the more accurate the CTP (at the cost of bandwidth).	Navigation Using LINK-16 GPS-INS Integration	Time HH:MM:SS Unit ID 5 diget Position MGRS Altitude Feet Direction of movement Deg Speed KPH Confidence Factor(Position, Alt, Time)	Depends on bandwidth available. At a minimum every 5 seconds for air 30 sec for ground User pref	2kb
IER-BF-04	Load Status	An optional "add on" to PLI information, used in Link 16 to report weapons load out and fuel states in addition to location information. This would make the file slightly larger but does not need to be transmitted near as often as PLI (maybe as infrequently as every minute vice every 5 seconds. The component may have different fields depending on its function. Humans and machines will have unique loads. Fuel level will be presented using this report for applicable components. A PMC alert will be issued when a component has 15 (or 20, or 30) minutes time on station before needing to return for fuel. A NMC alert would then be issued as the component checks off station, notifying the team that this component is no longer available.	N/A	Human: Ammo Battery quantity Medical Supplies Machine: Fuel Battery life	On Demand / auto every minute	2kb

C. COMMON TACTICAL PICTURE

KEY	Information Exchange	Content	Reference	Notes	Peridicoty	Size of File
IER-CTP-01	Common Tactical Picture (CTP) data	Common Tactical Picture (CTP). An accurate and complete display of relevant tactical data that integrates tactical information from the multi-tactical data link network, ground network, intelligence network, and sensor networks. Comprised of other information exchanges consisting of blue, red, green, PLI, control measures, CID, METOC and weather, etc. This includes fused track data from the higher Common Operational Picture that has been fused with specific mission information required to conduct tactical missions and is used to create the Common Tactical Picture. The CTP facilitates collaborative planning and assists all echelons to achieve situational awareness.	JP 1-02, MCWP 3-25.10	The common tactical picture is the "core" of the processes run in UTACC. This picture is developed during planning and is continuously refined during execution. Blue/Red/Neutral will all have various amount of the PLI information listed under Blue Force	Continouos	2 Kb
IER-CTP-02	Blue Force Information	Data consisting of PLI, Unit/Platform ID, Combat Identification (CID) IFF Data, Platform Status/Health, Load Status, and other information to provide blue force battlefield situational awareness.	MCRP 2-3A	N/A	30 Seconds for ground 5 Seconds for Air User can costomize	2 Kb
IER-CTP-03	Red Force (Threat) information	Data consisting of location information, identification, entity status/health, and other information to provide situational awareness about enemy forces.	MCRP 2-3A	N/A	On Demand	2 Kb

IER-CTP-04	Green Force Information	Data consisting of location information, identification, entity status/health, and other information to provide situational awareness about civilian, non-combatant, or other neutral forces.	MCRP 2-3A	N/A	On Demand	2 Kb
IER-CTP-05	Airspace Control Measures (ACM)	Air Control includes airspace control measures which increase OAS effectiveness by ensuring the safe, efficient, and flexible use of airspace. Airspace control measures speed the handling of air traffic within the area of operations. Air C2 systems use airspace control measures to help control the movement of OAS aircraft over the battlespace. Both positive and procedural control are used to deconflict aircraft in the airspace. The Tactical Air Coordination Center (TACC) is the principal air C2 agency, senior to the Direct Air Support Center (DASC) and the Tactical Air Operations Center (TAOC). The TAOC uses positive control, usually at higher altitudes. The DASC is generally controlling lower altitudes via procedural control (deconflicting via voice commands to aircraft through altitude and sector deconfliction). The altitude boundary separating DASC and TAOC control is theatre dependent.	MCWP 3-23	Since the DASC uses procedural control of aircraft at lower altitudes (where UTACC air components fly), future work should address how UTACC will fit into our current airspace structure. Should there be a way for UTACC to communicate with the DASC and follow procedural control instructions? Or will the UTACC concept drive us to make major changes to how we currently deconflict aircraft at lower altitudes.	On Demand	100 Kb without graphics
IER-CTP-06	Fire Support Coordination Measures (FSCM)	The overlay contains planned targets, FSCMs, unit positions, and other related information.	MCDP 1-0, JP 1-02, MCRP 5-12C	Examples of fire support control measure graphics (Fire Support Coordination Line, Restricted Fire Areas, No Fire Areas, etc)	On Demand	100 Kb without graphics
IER-CTP-07	Ground/Maneuver Control Measures	Graphical control measures that define Unit Boundaries, Phase Lines (PL), Routes, Assembly Areas, Objectives, Checkpoints, Obstacles, etc.	MCDP 1-0, JP 1-02, MCRP 5-12C	N/A	On Demand	100 Kb without graphics

IER-CTP-08	METOC Information	Information relating to the state of the atmosphere at a given time and place; usually described by specification variables such as temperature, moisture, wind velocity, and barometric pressure. Can include information such as fog, illumination, and visibility. Includes information needed for the Intelligence Preparation of the Operational Environment (IPOE), Geographical Intelligence (GEOINT) integration, and tailored information that analyzes the Electro-Optical spectrum against environmental conditions. This information supports the ability to attain situational dominance over the operational area through effective integration of METOC products and intelligence into the decision-making and planning processes.	MCRP 2-3A, MCWP 3-35.7, MCWP 2-1, MCWP 2-3, MCWP 2-26, MCWP 5-0, JP 3-59, CJCSI 3810.01	N/A	Continous	2 Kb
IER-CTP-09	Sensor data	Access to streaming video from UAS platforms. May range from "real time" to "near real time" depending on network access. Data may consist of information other than video, to include telemetry, signals, METOC or other information depending on supporting UAS platforms. Processed sensor data that provides near-real time reporting of activity in the surveillance area to include remote weather systems.	MCRP 2-3A	N/A	Continous	Varies depending on Sensor
IER-CTP-10	Identification Friend or Foe (IFF)	IFF is the capability to differentiate potential targets—mobile and fixed, over large areas with corresponding long distances—as friend, foe, or neutral in sufficient time, with high confidence, and at the requisite range to support engagement decisions and weapon release. Modern IFFs come in two varieties: Sensors—the target is characterized either noncooperatively (e.g., jet engine modulation, high-range resolution radar, or electronic support measures) or cooperatively (e.g., MK XII identification friend or foe (IFF) system or Battlefield Combat Identification System (BCIS)). C3 (particularly digital datalinks and radios)—the target declares (either periodically or when queried) its identification and position in a reference frame that the "shooter" can correlate with its own weapon and sensor system (e.g., Link 16). Both approaches have their strengths and limitations. If the identification is determined by an offboard sensor, there is the added necessity to pass and correlate the required information in a timely fashion. This requirement to correlate an identification label with a sensor return in the "weapon sight" is a key discriminator and a source of significant cost for the systems.	Joint Warfighting S&T Plan (JWSTP), Chapter 6	Chapter 6 of the Joint Warfare Science and Technology Plan lists many of the current sensors used to distinguish friend from foe. If UTACC components could be outfitted with theses sensors this could result in a reduction of fratricide if that information could be passed to the human agents in a timely manner.	On Demand	2 kb

D. SYSTEM UPDATES

KEY	Information Exchange	Content	Reference	Notes	Peridicoty	Size of File
IER-SU-01	Daily Intelligence Brief	A detailed briefing on weather, enemy, terrain, and friendly to include: sunrise/sunset, illumination, significant events, BOLOs, time sensitive information, enemy TTP updates, significant enemy IO/Counter-IO actions, terrain updates and scheduled collection plan.	MCRP 2-3A	N/A	Daily	5 Mb w/ graphics
IER-SU-02	Debrief Information	Debriefing information collected after patrols (includes cordon and knock patrols), no consistent formats across units. A Patrol Debrief will be conducted every time a patrol returns from a mission. The Intelligence Representative conducting the debrief will utilize the given format as a guide to assist in the overall intelligence collection effort, by answering PIRs/IRs assigned for collection.	MCRP 2-3A	N/A	On Demand	100 Kb without graphics
IER-SU-03	Request for Information (RFI)	Any specific time-sensitive ad hoc requirement for intelligence information or products to support an ongoing crisis or operation not necessarily related to standing requirements or scheduled intelligence production. A request for information can be initiated to respond to operational requirements and will be validated in accordance with the combatant command's procedures. The National Security Agency/Central Security Service also uses this term to state ad hoc signals intelligence requirements.	JP 2-0, JP 1-02, MCWP 5-1	N/A	On Demand	50 Kb

IER-SU-04	Execution Checklist/ Matrix Dissemination	A sequential listing of the key steps or activities to support the synchronization of all participants in a planned operation.	Plt CDR Notebook	N/A	On Demand	2 Kb
IER-SU-05	Mission Card Information / Profile	A report identifying mission related data to include: Unit identification, mission type, time of departure and return, routes, areas patrolled, personnel numbers, vehicle types and quantities, and C2 information (e.g. call sign, frequency, etc.) Passed daily	MCWP 2-25 Draft	N/A	On Demand	5 Mb w/ graphics
IER-SU-06	Fragmentary Order	An abbreviated form of an operation order issued as needed after an operation order to change or modify that order or to execute a branch or sequel to that order. Also called FRAGORD.	JP 1-02, MCWP 5-1	N/A	On Demand	100 Kb without graphics
IER-SU-07	Order to Abort	An order to terminate a mission for any reason other than enemy action. It may occur at any point after the beginning of the mission and prior to its completion.	JP 1-02	N/A	On Demand	2 Kb

E. REPORTS

KEY	Information Exchange	Content	Reference	Notes	Peridicoty	Size of File
IER-RP-01	Bridge Report	A report identifying pertinent bridge information to include: unit of measurement used, location, vertical and horizontal clearances, bridge length, type, and composition, bridge condition, road condition, and by-pass information.	MCRP 2-25A	A - Units of Measurment B - Location C - Horazontal Clearance(width) D - Under-bridge Clearance E - Spans (Number,Material,Type) F - Length and Condition of Span G - Overall length H - Roadway width J - Overhead Clearance J1 - Left Shoulder J2 - Center of Roadway J3 - Right Shoulder K - Bridge Bypass Potential K1 - Location of Bypass K2 - Overall Potential K3 - Description of Bypass K4 - Bypass restrictions (Height, Width) L - Remarks	On Demand	2 Kb
IER-RP-02	Route and Road Report	Self explanitory	MCRP 2-25A	A. Units of Measurement. B. Location (Start, Finish) C. Type of Route (Codes) D. Military Classification (Codes) E. Width (Surface, +Shoulders) F. Route Constrictions (list each) F1. Nature of constriction (Codes) F2. Location of the constriction F3. Dimension of the constriction F4. Bypass potential of the constriction (Codes) G. Concealment from Air (Codes) H. Special Considerations (Weather affects to route Codes) J. Remarks	On Demand	2 Kb

IER-RP-03	Obstacle Report	A message from addressee identifying obstacle data to include: map sheet reference, location, size, type, composition, orientation, estimated time to breach and/or by-pass, and gaps/lanes through obstacle.	MCRP 2-25A	1 - DTG 2 - Unit Making Report 3 - Emplacing Unit, if Known (Enemy, Friendly Unit, Unit) 4 - Approving Authority 5 - Target/Obstacle Number, if Known 6 - Type of Emplacing System, if Known 7 - Type Mines/Obstacle, if Known Include Width and Depth 8 - Type Minefield/Obstacle Marking System, if Emplaced 9 - DTG of Life Cycle/Self-Destruct Time, if Known 10 - Grid Zone Designator of Corners 11 - Obstacle/Minefield Reduced (Yes or No) 12 - Number of Lanes 13 - Reduction asset used 14 - Width of Lane 15 - Depth of Lane 16 - Grid To Start of Lane 17 - Grid To Exit 18 - Lane Marking 19 - Bypass (Yes or No) 20 - Bypass Grid 21 - Barriers 22 - Remarks		
IER-RP-04	Contact Report	A message from addressee identifying, call sign, date/time of contact, type of contact, actions taken, support requirements needed and other information pertinent to the contact. Pass As Required. SALTA reports when working with Coalition.	MCRP 2-25A	C—Call sign. "(Receiver's call sign) this is (originator's call sign)." O—Occurrence. Describes the type of contact/what has happened. N—Needs. States medical evacuation, emergency extraction, immediate suppression, reinforcement, resupply, and other needs. T—Time/Location. Indicates at what time the contact took place and T—Time/Location. Indicates at what time the contact took place and T—Time/Location. Indicates at what time the contact took place and where. These coordinates do not need to be encrypted/shackled. A—Actions Taken. Describes what the patrol has done since the contact was made, for example, broken contact, E&E, or so on. C—Casualties. Reports friendly KIAs/WIAs and transmits kill numbers from the warning order/kill sheet to assist the medical evacuation when needed.	On Demand	2 Kb

IER-RP-05	Position Report (POSREP)	A message from the addressee containing friendly and enemy location, enemy contact, and date/time information. This includes PLI.	MCRP 2-25A	POSREP. Grid, over.	On Demand	2 Kb
IER-RP-06	SALUTE Report	A report of enemy presence to include: size, activity, location, unit, time and equipment.	MCRP 2-25A	Size Activity Location Unit Time Equipment. Abbreviated version Size, Activity, Location, Time, Result (SALT-R) and SALT-A (Action)	On Demand	2 Kb
IER-RP-07	Situation Report (SITREP)	A report giving the situation in the area of a reporting unit or formation. Also called SITREP. It identifies actions that have occurred during a set period of time, future planned actions, personnel status, logistics status/requirements, date/time, and other pertinent information. Can include the engagement results, or the post analysis of air defense missile encounter.	MCRP 2-25A	1. DTG 2. Friendly position 3. Activities conducted (since last report) 4. Actions planned (next 12-hour period) 5. Logistical requirements (food, ammunition, pyrotechnics, water) 6. Personnel casualties (since last CASREP) 7. Remarks	On Demand	2 Kb
IER-RP-08	Spot Report (SPOTREP)	A concise narrative report of essential information covering events or conditions that may have an immediate and significant effect on current planning and operations that is afforded the most expeditious means of transmission consistent with requisite security. Note: In reconnaissance and surveillance usage, spot report is not to be used.	MCRP 2-25A	A. Units of Measurement. B. Size (Codes) C. Activity (Codes) D. Location. E. Unit. F. Time. The DTG of the sighting G. Equipment. H. Remarks.	On Demand	2 Kb
IER-RP-09	Acknowledgment	A message from the addressee informing the originator that his or her communication has been received and is understood.	MCRP 5-2A, FM 101-5-2	It is important that UTACC components receive confirmation of message receipt. Not only to ensure the message does not need to be re-sent, but also to confirm that the recipient is still in the network. This system of acknowledgement could be a way that UTACC discovers a component has been destroyed, aiding in graceful degredation.	On Demand	2 Kb
IER-RP-10	Downed Aircraft Status	The condition of an aircraft that has been brought to the ground, especially by force.	MCWP 5-11.1 TRAP	Important information for UTACC for graceful degredation and asset retrieval purposes.	On Demand	2 Kb

IER-RP-15	Maintenance Support Request	A request for maintenance support includes: unit, location, vehicle/equipment identification information, vehicle/equipment symptoms/issue, delivery location, type of contact team requested and relevant coordinating information.	Department of the Army Pamphlet 750–1	1 -- DATE AND TIME 2 -- UNIT(Unit Making Report) 3 -- REQUESTING AGENCY 4 -- LOCATION 5 -- DATE(Date Maintenance Support is Required) 6 -- NOMENCLATURE 7 -- NO. PIECES 8 -- TYPE (Type of Support Required) **Repeat lines 3 through 8 for each type of equipment requiring maintenance support. 9 -- EQUIPMENT LOCATION 10 -- CONDITION 11 -- SPECIAL INSTRUCTIONS 12 -- COORDINATION 13 -- NARRATIVE 14 -- AUTHENTICATION	On Demand	2 Kb
IER-RP-16	Vehicle Recovery Request	A Vehicle Recovery Request will notify the Bn CP of a disabled vehicle which requires Bn maintenance assets to recover and or repair. Precedence/Classification. Priority/Confidential. Reporting Time. When appropriate. THIS IS "DISABLED VEHICLE REP, OVER" (ADDRESSEE) (ORGINATOR)	Department of the Army Pamphlet 750–1	1 - Type of vehicle 2 - Grid location 3 - Time inoperable 4 - Symptoms 5 - Estimate of parts necessary to repair 6 - Special tools necessary to repair DTG:	On Demand	2 Kb
IER-RP-17	Casualty Evacuation (CASEVAC) Request	A message from the addressee requesting evacuation of injured personnel. The request includes number of casualties, priorities, casualty identifying information, special transport requirements and pertinent C2 coordination information (e.g., coordinates, call sign, radio frequencies, etc.).	MCRP 2-25A	1 - Location 2 - Radio Frequency, Call Sign 3 - Number with Precedence (Urgent, Urgent Surgical, Priority, Routine) 4 - Special Equipment (Codes) 5 - Number of Patients by Type (L -Litter, A - Ambulatory) 6 - Security of Pickup Site (codes) 7 - Method of Marking Pickup Site (Codes) 8 - Patient's Nationality and Status (Codes) 9 - NBC Contamination (N, B, C) May also include MIST info A report between medical personnel that gives: Patient ID, the Mechanism of Injury, Type of injury, Signs (vitals), and Treatment given.	On Demand	2 Kb

IER-RP-11	Landing Zone (LZ) Report	A report identifying helicopter landing zone information to include: map reference, coordinates, LZ shape, LZ size, LZ terrain composition, recommended ingress and egress, navigation aids and unit identifying LZ. (Includes LZ Brief).	MCRP 3-11-1a	1. Mission Number (Assigned to Helicopter) 2. Location: (Coordinate) 3. Unit Callsign (Ground) 4. Frequency (Radio, include secondary) 5. LZ marking (ex: green smoke) 6. Wind Direction/Velocity 7. Elevation/Size/Shape of LZ 8. Obstacles 9. Friendly positions 10. Enemy positions 11. Last fire recieved (time/type) 12. Direction of fire and distance 13. Clearance to fire (direction/distance) 14. Recommended approach direction 15. Personnel/Equipment 16. Other	On Demand	2 Kb
IER-RP-12	Personnel Status (PERSTAT)	A report identifying personnel strength. It includes the numbers and types of unit personnel to include organic, new joins/drops, attachments, and detachments.	Plt CDR Notebook	1. Marine Officers 2. Marine Enlisted 3. Navy Officers 4. Navy Enlisted 5. Others	On Demand	2 Kb
IER-RP-13	Casualty Report (CASREP)	A report submitted by a subordinate unit that provides information on unit casualties to the personnel section. Information to include: number of officer and enlisted WIA, KIA and MIA, criticality of casualties (e.g., fair, critical, etc.), hostile/non-hostile related, and individual casualty information to include, name, rank, nature of wound and status.	MCRP 2-25A	1. DTG 2. KIA 3. WIA 4. MIA Six Column Report for reporting friendly Casualties Rank Name SSN Unit Type of Wound Evacuation Status	On Demand	2 Kb
IER-RP-14	Intelligence Report (INTREP)	The intelligence report (INTREP) is a standardized report that is disseminated as rapidly as possible based on its importance to the current situation. This report is the primary means for transmitting new and significant information and intelligence when facts influencing threat capabilities have been observed or when a change in threat capabilities has taken place.	MCRP 2-25A MCRP 2-3A		On Demand	2 Kb

APPENDIX D. TASK ANALYSIS WORKSHEETS

SEE FOLLOWING PAGE

A. INITIALIZE SYSTEM AND SET PREFERENCES

TASK NAME Initialize System and Set Preferences	**TASK ABBREVIATION** PLNG.BP.ISSP
CATALOG NUMBER 1.1	**PARENT/PREVIOUS TASK(S)** None
CHILD/SUBSEQUENT TASK(S) Enter Mission Parameters (1.2)	**PARALLEL TASK(S)** None
TASK SUMMARY The user performs guided system initialization. This will include calibration of any sensors for natural language processing and human motion recognition as well as ensuring all subsystems (e.g. UAVs, UGVs) are correctly incorporated into the UTACC system. The User will also set any user defined preferences for default formation, sensor posture and actions to be taken in immediate action scenarios. Once this is completed the system would then be operational and ready to receive mission inputs and begin any required mission planning.	
REFERENCE DOCUMENTS None	
PLANNING FACTORS	
THREAT ANALYSIS Omitted	
CONDITIONS N/A	
ASSUMPTIONS None	
RESOURCES **1.** Small Tactical Unit Leader **2.** UTACC **a.** User Interface System **b.** Air Carrier **c.** UAV 1 **d.** UAV 2 **e.** Ground Carrier **f.** UGV 1 **g.** UGV 2	
SPECIFIED TASKS UTACC will initialize to the user and components in order to proceed with mission planning and execution.	
IMPLIED TASKS None	

LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R]) None
SHORTFALLS N/A
UTACC ACTIONS
INPUTS Voice and motion generated by authorized user
PROCESS Conduct subsystem checks to ensure that the current status of all UTACC components is known and any repairs or exchanges can be made prior to mission execution. Calibrate natural language processing and human motion recognition sensors to users. Incorporate all major subsystems to ensure good communications links are established between components. Establish communications with Higher command.
OUTPUTS UTACC prompt for user to enter mission parameters
ASSOCIATED IERs **1.** IER SB-01, 02, 03, 04, 10 **2.** IER BF-02, 03, 04 **3.** IER CTP-08 **4.** IER SU-01, 05, 06

B. ENTER MISSION PARAMETERS

<table>
<tr><td><u>TASK NAME</u>
Input Mission Parameters</td><td><u>TASK ABBREVIATION</u>
PLAN.BP.IMP</td></tr>
<tr><td><u>CATALOG NUMBER</u>
1.2</td><td><u>PARENT/PREVIOUS TASK(S)</u>
Initialize System and Set Preferences (1.1)</td></tr>
<tr><td><u>CHILD/SUBSEQUENT TASK(S)</u>
Conduct Initial Mapping for Orientation (2.1)</td><td><u>PARALLEL TASK(S)</u>
N/A</td></tr>
<tr><td colspan="2"><u>TASK SUMMARY</u>
The user or higher headquarter gives the UTACC system initial mission inputs. This could be a verbal order from the user, a hardcopy written order or a digital transmission. These inputs will be in 5 paragraph order format. The system will take this order and process it so that the system is correctly oriented to the mission and can begin mapping or other mission planning steps are required to present the user with various mission profiles to choose from.</td></tr>
<tr><td colspan="2"><u>REFERENCE DOCUMENTS</u>
None</td></tr>
<tr><td colspan="2">PLANNING FACTORS</td></tr>
<tr><td colspan="2"><u>THREAT ANALYSIS</u>
Omitted</td></tr>
<tr><td colspan="2"><u>CONDITIONS</u>
N/A</td></tr>
<tr><td colspan="2"><u>ASSUMPTIONS</u>
None</td></tr>
<tr><td colspan="2"><u>RESOURCES</u>
1. Small Tactical Unit Leader
2. UTACC
a. User Interface System
b. Air Carrier
c. UAV 1
d. UAV 2
e. Ground Carrier
f. UGV 1
g. UGV 2</td></tr>
<tr><td colspan="2"><u>SPECIFIED TASKS</u>
UTACC will orient to current mission in order to begin mission planning.</td></tr>
<tr><td colspan="2"><u>IMPLIED TASKS</u>
None</td></tr>
<tr><td colspan="2"><u>LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R])</u>
None</td></tr>
</table>

SHORTFALLS N/A
UTACC ACTIONS
INPUTS UTACC will receive from the User or higher headquarters, in 5 paragraph order format.
PROCESS UTACC processes the new mission information and prepares to execute mission planning.
OUTPUTS Prompt to user to begin mission planning steps.
Associated IERs **1.** IER SB-01, 02, 03, 04, 05, 06, 07, 08, 09, 10, 11 **2.** IER BF-02, 03, 04 **3.** IER CTP-08 **4.** IER SU-01, 05, 06

C. CONDUCT INITIAL MAPPING FOR ORIENTATION

TASK NAME Conduct Initial Mapping for Orientation	**TASK ABBREVIATION** PLNG.AR.INIMAP
CATALOG NUMBER 2.1	**PARENT/PREVIOUS TASK(S)** Enter Mission Parameters (1.2)
CHILD/SUBSEQUENT TASK(S) Select Emphasis Area(s) (2.2)	**PARALLEL TASK(S)** None

TASK SUMMARY
This unit must organically map their Area of Operations (AO). Initial mapping will provide a basic orientation that will be further refined by selecting emphasis areas for more detailed mapping. Sensors will be required to obtain Digital Terrain Elevation Data (DTED) and distinguish between types of terrain in order to provide data sufficient for orientation purposes.

REFERENCE DOCUMENTS
None

PLANNING FACTORS

THREAT ANALYSIS
Omitted

CONDITIONS
N/A

ASSUMPTIONS
None

RESOURCES

1. Small Tactical Unit Leader
2. UTACC
   - **a.** User Interface System
   - **b.** Air Carrier
   - **c.** UAV 1
   - **d.** UAV 2
   - **e.** Ground Carrier
   - **f.** UGV 1
   - **g.** UGV 2

SPECIFIED TASKS
UTACC will use all available resources to create an initial digital map of the AO in order to proceed with mission planning.

IMPLIED TASKS
None

LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R])
None

SHORTFALLS N/A
UTACC ACTIONS
INPUTS The area to be mapped. This should include the AO and an operator defined margin to gain orientation of areas adjacent to the AO.
PROCESS **1.** The Air Component executes a collaborative plan built by UTACC software to map the AO efficiently while minimizing overlap between sensors. This plan uses the principle of dynamic resource allocation meaning that UTACC decides how to best employ the assets. **2.** The Ground Component executes a collaborative plan built by UTACC software to map the immediate area of the small tactical unit. This can potentially serve as a force protection measure if Ground Component assets/sensors are placed on likely avenues of approach to augment the small tactical unit's local security plan.
OUTPUTS An initial map that has enough information for the small tactical unit to have an orientation to their AO and be able to select emphasis areas.
ASSOCIATED IERs **1.** IER SB-05, 09, 10 **2.** IER CTP-05, 06, 07, 08 **3.** IER RP- 01, 02, 03

D. SELECT EMPHASIS AREA(S)

<u>TASK NAME</u> Select Emphasis Area(s)	**<u>TASK ABBREVIATION</u>** PLNG.AR.EA
<u>CATALOG NUMBER</u> 2.2	**<u>PARENT/PREVIOUS TASK(S)</u>** Conduct Initial Mapping for Orientation (2.1)
<u>CHILD/SUBSEQUENT TASK(S)</u> Conduct Detailed Mapping (3.1)	**<u>PARALLEL TASK(S)</u>** None

<u>TASK SUMMARY</u>
The Small Tactical Unit Leader will have an orientation of the Area of Operations (AO) after the initial mapping of is complete. This information will allow the small tactical unit to select areas which require more detailed mapping (higher resolution, improved Digital Terrain Elevation Data (DTED)). This step focuses resources to specific areas instead of the whole area which will save time in the planning process.

<u>REFERENCE DOCUMENTS</u>
None

PLANNING FACTORS

<u>THREAT ANALYSIS</u>
Omitted

<u>CONDITIONS</u>
N/A

<u>ASSUMPTIONS</u>
Initial mapping data is sufficient to designate emphasis areas.

<u>RESOURCES</u>
1. Small Tactical Unit Leader
2. UTACC
   a. User Interface System

<u>SPECIFIED TASKS</u>
The Small Tactical Unit Leader will select emphasis areas from the initial orientation map created by UTACC.

<u>IMPLIED TASKS</u>
None

<u>LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R])</u>
None

<u>SHORTFALLS</u>
N/A

UTACC ACTIONS
INPUTS The initial orientation map created by UTACC. This should include the AO and the operator defined margin of areas adjacent to the AO.
PROCESS The Small Tactical Unit Leader selects emphasis areas via the UIS.
OUTPUTS The initial map with emphasis areas selected causes UTACC to plan and dynamically resource a plan to map the selected areas.
ASSOCIATED IERs **1.** IER SB-05, 09, 10 **2.** IER CTP-05, 06, 07, 08 **3.** IER RP- 01, 02, 03

E. CONDUCT DETAILED MAPPING

TASK NAME Conduct Detailed Mapping	**TASK ABBREVIATION** PLNG.MR.DETMAP
CATALOG NUMBER 3.2	**PARENT/PREVIOUS TASK(S)** Select Emphasis Area(s) (2.2)
CHILD/SUBSEQUENT TASK(S) Complete MCOO (M.1)	**PARALLEL TASK(S)** Complete MCOO (M.1) [elements of this task can be done in parallel]
TASK SUMMARY UTACC uses dynamic resource allocation between all available sensors to obtain Digital Terrain Elevation Data (DTED) and distinguish between types of terrain for the specified emphasis areas in order to build the foundation of information required to generate a Modified Combined Obstacle Overlay (MCOO; e.g., vegetation effects, surface drainage effects). If the data is insufficient, the UIS will provide feedback (via cue or alert) to the small tactical unit.	
REFERENCE DOCUMENTS None	
PLANNING FACTORS	
THREAT ANALYSIS Omitted	
CONDITIONS N/A	
ASSUMPTIONS None	
RESOURCES **1.** Small Tactical Unit Leader **2.** UTACC **a.** User Interface System **b.** Air Carrier **c.** UAV 1 **d.** UAV 2 **e.** Ground Carrier **f.** UGV 1 **g.** UGV 2	
SPECIFIED TASKS UTACC will use all available resources to create a refined digital map of the designated emphasis areas in order to proceed with mission planning.	
IMPLIED TASKS None	
LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R]) None	

SHORTFALLS N/A
UTACC ACTIONS
INPUTS The refined digital map with emphasis areas selected.
PROCESS **1.** The Air Component continues to employ dynamic resource allocation to gain the detailed mapping required for the mission based off of the emphasis areas from the previous step. **2.** The Ground Component continues to map the immediate area of the small tactical unit and augment the local security plan. The ground component can also conduct detailed mapping of emphasis areas if required in the immediate proximity of the small tactical unit. **3.** When data is sufficient in a certain area, UTACC may begin to develop the simultaneous MCOO for that area to save time rather than wait until all detailed mapping is complete
OUTPUTS The overlay of the detailed mapping is layered on top of the initial map.
ASSOCIATED IERs **1.** IER SB-05, 09, 10 **2.** IER CTP-05, 06, 07, 08 **3.** IER RP- 01, 02, 03

F. MODIFIED COMBINED OBSTACLE OVERLAY (SUBPROCESS)

1. Complete MCOO

TASK NAME Complete Modified Combined Obstacle Overlay (MCOO)	**TASK ABBREVIATION** PLNG.MCOO
CATALOG NUMBER M.1	**PARENT/PREVIOUS TASK(S)** Conduct Detailed Mapping (3.1)
CHILD/SUBSEQUENT TASK(S) Depict Vegetation Effects (M.1.1) Depict Surface Drainage Effects (M.1.2) Depict All Other Effects (M.1.3) Depict Mobility Corridors and Avenues of Approach (M.2)	**PARALLEL TASK(S)** None

TASK SUMMARY

The modified combined obstacle overlay (MCOO) is a graphic of the battlespace's effects on military operations. It is normally based on a product depicting all obstacles to mobility and it is modified as necessary. Modifications can include cross country mobility classifications, objectives, avenues of approach and mobility corridors, likely obstacles, defensible battlespace, likely engagement areas, key terrain, cultural factors, built-up areas, and civil infrastructure. [Ref 1, app E]

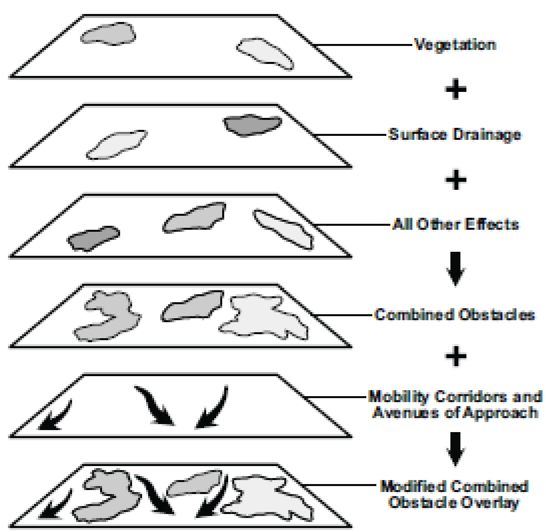


Figure E-1. Modified Combined Obstacle Overlay.

REFERENCE DOCUMENTS

1. MCWP 5–1

PLANNING FACTORS

THREAT ANALYSIS

Omitted

CONDITIONS N/A
ASSUMPTIONS UTACC generated map data is sufficient for MCOO.
RESOURCES **1.** UTACC   **a.** User Interface System
SPECIFIED TASKS UTACC will produce a MCOO in order to proceed with mission planning and execution.
IMPLIED TASKS None
LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R]) None
SHORTFALLS None
UTACC ACTIONS
INPUTS **1.** Raw 3D Map. **2.** Vegetation Effects Overlay. **3.** Surface Drainage Effects Overlay. **4.** All Other Effects Overlay. **5.** Mobility Corridors and Avenues of Approach Overlay.
PROCESS UTACC will fuse the five inputs into one product (MCOO).
OUTPUTS Refined 3D map with MCOO
ASSOCIATED IERs **1.** IER-CTP-07, 08 **2.** IER-RP-01, 02, 03 **3.** IER-SB-09, 10, 13

2. Vegetation Effects

TASK NAME Depict Vegetation Effects	**TASK ABBREVIATION** PLNG.MCOO.VEG
CATALOG NUMBER M.1.1	**PARENT/PREVIOUS TASK(S)** Complete Modified Combined Obstacle Overlay (M.1)
CHILD/SUBSEQUENT TASK(S) Depict Mobility Corridors and Avenues of Approach (M.2)	**PARALLEL TASK(S)** Depict Surface Drainage Effects (M.1.2) Depict All Other Effects (M.1.3)

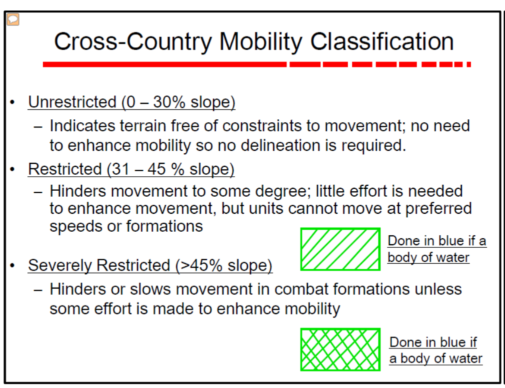
TASK SUMMARY

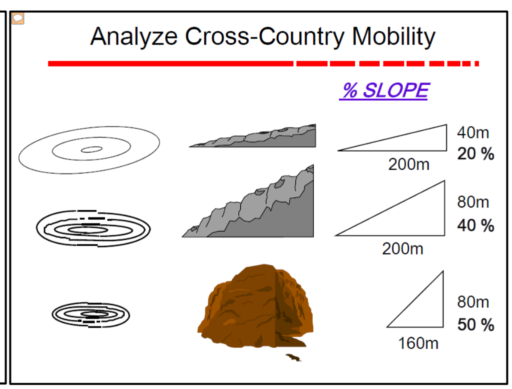
In order to complete the Modified Combined Obstacle Overlay (MCOO), the effects of vegetation must be analyzed. The vegetation category includes type of vegetation, tree spacing, trunk diameter, soil types, and conditions that affect mobility. [Ref 1, ch 4]

Severely restricted terrain severely hinders or slows movement in combat formations unless some effort is made to enhance mobility. This could take the form of committing engineer assets to improving mobility or deviating from doctrinal tactics, such as moving in columns instead of line formations, or at speeds much lower than those preferred. For example, severely restricted terrain for armored and mechanized forces is typically characterized by steep slopes and large or densely spaced obstacles with little or no supporting roads. A common technique is to depict this type of severely restricted terrain on overlays and sketches by marking the areas with crosshatched diagonal lines. Another technique is to color code the areas in red. [Ref 1, para 4–55]

Restricted terrain hinders movement to some degree. Little effort is needed to enhance mobility, but units may have difficulty maintaining preferred speeds, moving in combat formations, or transitioning from one formation to another. Restricted terrain slows movement by requiring zigzagging or frequent detours. Restricted terrain for armored or mechanized forces typically
consists of moderate-to-steep slopes or moderate-to-densely spaced obstacles, such as trees, rocks, or buildings. Swamps or rugged terrain are examples of restricted terrain for dismounted infantry forces. Logistical or sustainment area movement may be supported by poorly developed road systems. A common and useful technique is to depict restricted terrain on overlays and sketches by marking the areas with diagonal lines. Another technique is to color code the areas in yellow. [Ref 1, para 4–55]

Unrestricted terrain is free of any restriction to movement. Nothing needs to be done to enhance mobility. Unrestricted terrain for armored or mechanized forces is typically flat to moderately sloping terrain with scattered or widely spaced obstacles such as trees or rocks. Unrestricted terrain allows wide maneuver by the forces under consideration and unlimited travel supported by well-developed road networks. No symbology is needed to show unrestricted terrain on overlays and sketches. [Ref 1, para 4–55]





REFERENCE DOCUMENTS **1.** MCRP 2–3A	

PLANNING FACTORS

THREAT ANALYSIS
Omitted

CONDITIONS
N/A

ASSUMPTIONS
UTACC generated map data is sufficient for MCOO.

RESOURCES
1. UTACC
   a. User Interface System

SPECIFIED TASKS
UTACC will analyze map data and determine the vegetation effects in order to produce a MCOO.

IMPLIED TASKS
None

LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R])
None

SHORTFALLS
None

UTACC ACTIONS

INPUTS
Raw 3D Map.

PROCESS
UTACC will create a vegetation effects overlay based on the Raw 3D Map. The task summary has key definitions that enable this task (severely restricted, restricted, unrestricted terrain).

OUTPUTS
Vegetation Effects Overlay

ASSOCIATED IERs
1. IER-CTP-07, 08
2. IER-RP-01, 02, 03
3. IER-SB-09, 10, 13

3. Surface Drainage

TASK NAME	TASK ABBREVIATION
Depict Surface Drainage Effects	PLNG.MCOO.DRAIN
CATALOG NUMBER M.1.2	**PARENT/PREVIOUS TASK(S)** Complete Modified Combined Obstacle Overlay (M.1)
CHILD/SUBSEQUENT TASK(S) Depict Mobility Corridors and Avenues of Approach (M.2)	**PARALLEL TASK(S)** Depict Vegetation Effects (M.1.1) Depict All Other Effects (M.1.3)
TASK SUMMARY In order to complete the Modified Combined Obstacle Overlay (MCOO), the effects of surface drainage must be analyzed. The surface drainage category includes water sources along with their: width, depth, velocity, bank slope, height, and potential flood zones. [Ref 1, ch 4]	
REFERENCE DOCUMENTS **1.** MCRP 2–3A	
PLANNING FACTORS	
THREAT ANALYSIS Omitted	
CONDITIONS N/A	
ASSUMPTIONS UTACC generated map data is sufficient for MCOO.	
RESOURCES **1.** UTACC **a.** User Interface System	
SPECIFIED TASKS UTACC will analyze map data and determine the surface drainage effects in order to produce a MCOO.	
IMPLIED TASKS None	
LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R]) None	
SHORTFALLS None	
UTACC ACTIONS	
INPUTS Raw 3D Map.	

PROCESS UTACC will create a surface drainage effects overlay based on the Raw 3D Map. The task summary has key definitions that enable this task (severely restricted, restricted, unrestricted terrain).
OUTPUTS Surface Drainage Effects Overlay
ASSOCIATED IERs **1.** IER-CTP-07, 08 **2.** IER-RP-01, 02, 03 **3.** IER-SB-09, 10, 13

4. All Other Effects (Weather/Environmental)

TASK NAME Depict All Other Effects	**TASK ABBREVIATION** PLNG.MCOO.OTH
CATALOG NUMBER M.1.3	**PARENT/PREVIOUS TASK(S)** Complete Modified Combined Obstacle Overlay (M.1)
CHILD/SUBSEQUENT TASK(S) Depict Mobility Corridors and Avenues of Approach (M.2)	**PARALLEL TASK(S)** Depict Vegetation Effects (M.1.1) Depict Surface Drainage Effects (M.1.2)

TASK SUMMARY

In order to complete the Modified Combined Obstacle Overlay (MCOO), all other effects in addition to vegetation and surface drainage must be analyzed. This category may include:

- Surface configuration (elevation, slopes that affect mobility, line of sight for equipment usage).
- Obstacles (natural and manmade).
- Transportation systems (bridge classification and road characteristics such as curve radius, slopes, and width).

[Ref 1, ch 4]

REFERENCE DOCUMENTS

1. MCRP 2–3A

PLANNING FACTORS

THREAT ANALYSIS

Omitted

CONDITIONS

N/A

ASSUMPTIONS

UTACC generated map data is sufficient for MCOO.

RESOURCES

1. UTACC
    a. User Interface System

SPECIFIED TASKS

1. UTACC will analyze map data and determine all other effects in order to produce a MCOO.

IMPLIED TASKS

None

LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R])

None

SHORTFALLS

None

UTACC ACTIONS
INPUTS Raw 3D Map
PROCESS UTACC will create an all other effects overlay based on the Raw 3D Map. The task summary has key definitions that enable this task (severely restricted, restricted, unrestricted terrain).
OUTPUTS All Other Effects Overlay
ASSOCIATED IERs **1.** IER-CTP-07, 08 **2.** IER-RP-01, 02, 03 **3.** IER-SB-09, 10, 13

5. Mobility Corridors and Avenues of Approach

TASK NAME	**TASK ABBREVIATION**
Depict Mobility Corridors and Avenues of Approach	PLNG.MCOO.MOB
CATALOG NUMBER M.2	**PARENT/PREVIOUS TASK(S)** Depict Vegetation Effects (M.1.1) Depict Surface Drainage Effects (M.1.2) Depict All Other Effects (M.1.3)
CHILD/SUBSEQUENT TASK(S) None	**PARALLEL TASK(S)** None

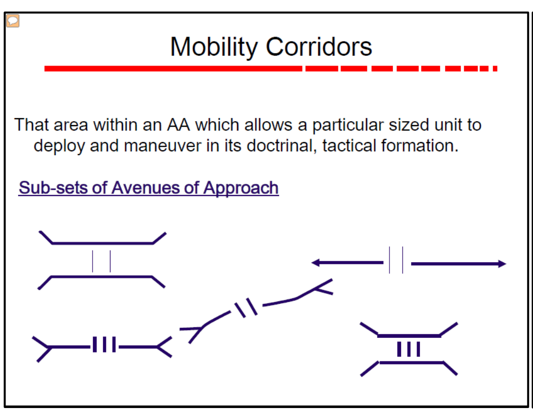
TASK SUMMARY

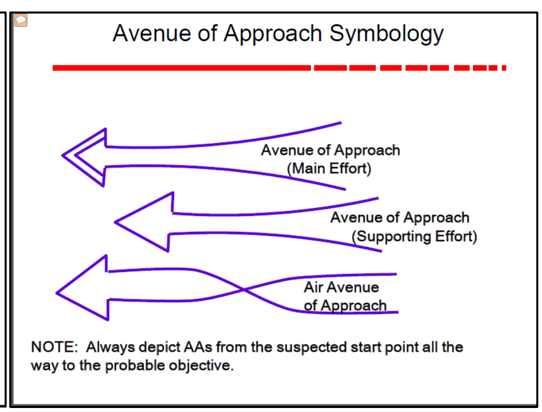
In order to complete the MCOO, the combination of vegetation effects, surface drainage effects, and all other effects must be analyzed together in order to depict mobility corridors and avenues of approach. [Ref 1, ch 4]

Mobility corridors are that are relatively free of obstacles where a force will be canalized due to terrain restrictions allowing military forces to capitalize on the principles of mass and speed. [Ref 1, para 4–20]

Mobility corridors, like obstacles, are a function of the type and mobility of the force being evaluated. Military forces, such as mechanized infantry or armored units, require large open areas in which to move and maneuver. Irregular forces are less impacted by the presence of obstacles and terrain that would hinder movement of a large formation. The size of a mobility corridor can be determined based on terrain constrictionsMobility corridors are categorized by the size or type of force they can accommodate. Mobility corridors can also be categorized by likely use. For example, a mechanized force requires logistical sustainment; a mobility corridor through unrestricted terrain supported by a road network is generally more desirable. A dismounted force might be able to use more restrictive corridors associated with the arctic tundra, swamps or marshes, jungles, or mountains that may or may not have a road network. Due to their rate of march and lack of fire power, dismounted forces require a more covered and concealed route for survivability to reach their objective. [Ref 1, para 4–22,23]

AAs are air or ground routes used by an attacking force leading to its objective or to key terrain in its path. The identification of AAs is important because all COAs that involve maneuver depend on available AAs. During offensive tasks, the evaluation of AAs leads to a recommendation on the best AAs to a command's objective and identification of avenues available to the enemy for counterattack, withdrawal, or the movement of reinforcements or reserves. In a defense operation, it is important to identify AAs that support enemy offensive capabilities and avenues that support the movement and commitment of friendly reserves. AAs are developed by identifying, categorizing, and grouping mobility corridors and evaluating AAs. [Ref 1, para 4–19]





REFERENCE DOCUMENTS
1. MCRP 2–3A

PLANNING FACTORS

THREAT ANALYSIS
Omitted

CONDITIONS
N/A

ASSUMPTIONS
UTACC generated map data is sufficient for MCOO.

RESOURCES
1. UTACC
   a. User Interface System

SPECIFIED TASKS
UTACC will analyze map data and determine the Mobility Corridors and Avenues of Approach Overlay based on the Raw 3D Map, Vegetation Effects Overlay, Surface Drainage Effects Overlay, and All Other Effects Overlay in order to produce a MCOO.

IMPLIED TASKS
None

LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R])
None

SHORTFALLS
None

UTACC ACTIONS

INPUTS
1. Vegetation Effects Overlay
2. Surface Drainage Effects Overlay
3. All Other Effects Overlay

PROCESS
UTACC will create a Mobility Corridors and Avenues of Approach Overlay based on the Vegetation Effects Overlay, Surface Drainage Effects Overlay, and All Other Effects Overlay. In order to do this, UTACC must distinguish areas to relatively free of obstacles and mark them as mobility corridors (a complete definition of mobility corridoors is found in the task summary). After mobility ccorridors are discovered, avenues of approaches can be created.

OUTPUTS
Mobility Corridors and Avenues of Approach Overlay

ASSOCIATED IERs
1. IER-CTP-07, 08
2. IER-RP-01, 02, 03
3. IER-SB-09, 10, 13

G. DEVELOP MISSION PROFILE(S)

TASK NAME Develop Mission Profile(s)	**TASK ABBREVIATION** PLNG.CP.DMP
CATALOG NUMBER 4.1	**PARENT/PREVIOUS TASK(S)** Conduct Detailed Mapping (3.1) Complete MCOO (M.1)
CHILD/SUBSEQUENT TASK(S) Refine Mission Profile (4.2)	**PARALLEL TASK(S)** N/A

TASK SUMMARY

Developing mission profile(s) is the first step in the "complete plan" swimlane. The final products derived from the "make reconnaissance" swimlane included a complete MCOO, which depicted areas of restricted terrain from the unit's present position to the objective area. Areas will have also been identified where movement is possible for the small tactical unit and/or the UxVs. These are referred to as "mobility corridors" or "avenues of approach." Once mobility corridors are identified, they will be the basis for the mission profiles developed by UTACC during this step of planning. UTACC should initially develop no more than four possible mission profiles for movement to the objective and present these profiles to the team leader via the UIS. This should trigger a cue to the team leader that several possible mission profiles are available for selection. Once mission profiles are presented via the user interface, the develop mission profile(s) step is complete.

REFERENCE DOCUMENTS

1. MCRP 2–3A

PLANNING FACTORS

THREAT ANALYSIS

Omitted

CONDITIONS

N/A

ASSUMPTIONS

None

RESOURCES

1. UTACC
   a. User Interface System

SPECIFIED TASKS

Develop mission profiles following Conduct Detailed Mapping and MCOO.

IMPLIED TASKS

None

LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R])

None

SHORTFALLS None
UTACC ACTIONS
INPUTS UTACC generated MCOO, complete with restricted terrain and mobility corridors.
PROCESS UTACC derives mobility corridors from places in the MCOO where terrain is not restrictive. These mobility corridors form the basis for mission profile options to be presented to the team leader.
OUTPUTS Cue to team leader via user interface that mission profiles are available for selection. Up to four possible routes to objective presented to the user interface system for selection.
ASSOCIATED IERs **1.** IER SB-09 **2.** IER CTP-01, 07, 09 **3.** IER SU-05 **4.** IER RP-02, 03

H. REFINE MISSION PROFILE(S)

<table>
<tr><td><u>TASK NAME</u>
Refine Mission Profile</td><td><u>TASK ABBREVIATION</u>
PLNG.CP.RMP</td></tr>
<tr><td><u>CATALOG NUMBER</u>
4.2</td><td><u>PARENT/PREVIOUS TASK(S)</u>
Develop Mission Profile (4.1)</td></tr>
<tr><td><u>CHILD/SUBSEQUENT TASK(S)</u>
Select Mission Profile (4.3)</td><td><u>PARALLEL TASK(S)</u>
N/A</td></tr>
<tr><td colspan="2"><u>TASK SUMMARY</u>
Refine mission profile begins when the team leader is presented with up to four possible mission profiles to the objective area via the UIS (the conclusion of the develop mission profile step). If one of the four mission profiles are acceptable to the team leader, this step may be skipped; proceed directly to 'Select Mission Profile' (Catalog Number 4.3). If the team leader determines that none of the four mission profiles are acceptable (such as due to threats, exposure, etc.), he may direct the UAVs to return to the 'Conduct Detailed Mapping' (Catalog Number 3.1) step in order to determine additional mobility corridors from the unit's present position to the objective area. The team leader should have the option to highlight areas for additional detailed mapping via the user interface system. Once the human rejects the UTACC generated mission profiles, the system should reset to the 'Make Reconnaissance' swimlane. This step in the planning process concludes with either a reset to a previous planning step, or when the team leader decides on an acceptable mission profile.</td></tr>
<tr><td colspan="2"><u>REFERENCE DOCUMENTS</u>
None</td></tr>
<tr><td colspan="2">PLANNING FACTORS</td></tr>
<tr><td colspan="2"><u>THREAT ANALYSIS</u>
Omitted</td></tr>
<tr><td colspan="2"><u>CONDITIONS</u>
N/A</td></tr>
<tr><td colspan="2"><u>ASSUMPTIONS</u>
There is sufficient information to initially develop at least one mission profile.</td></tr>
<tr><td colspan="2"><u>RESOURCES</u>
1. Small Tactical Unit Leader
2. UTACC
    a. User Interface System</td></tr>
<tr><td colspan="2"><u>SPECIFIED TASKS</u>
Return to conduct detailed mapping step in the make reconnaissance swimlane.</td></tr>
<tr><td colspan="2"><u>IMPLIED TASKS</u>
None</td></tr>
<tr><td colspan="2"><u>LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R])</u>
None</td></tr>
</table>

SHORTFALLS None
UTACC ACTIONS
INPUTS **1.** Team leader directs UTACC to return to conduct detailed mapping step of the planning process. **2.** Team leader selected additional areas for detailed mapping.
PROCESS **1.** UTACC prioritizes aerial reconnaissance of areas where team leader selected for emphasis. **2.** UTACC refines MCOO in an attempt to identify additional mobility corridors/avenues of approach. **3.** Once mobility corridors are identified, UTACC proceeds to 'Develop Mission Profile step (Catalog Number 4.1).
OUTPUTS Additional mission profiles presented to the user interface system along with a cue to the team leader.
ASSOCIATED IERs **1.** IER SB-09, **2.** IER CTP-01, 07, 09, **3.** IER SU-05 **4.** IER RP-02, 03

I. SELECT MISSION PROFILE

TASK NAME Select Mission Profile	**TASK ABBREVIATION** PLNG.CP.SMF
CATALOG NUMBER 4.3	**PARENT/PREVIOUS TASK(S)** Refine Mission Profile (4.2)
CHILD/SUBSEQUENT TASK(S) Submit to HHQ for approval (4.4)	**PARALLEL TASK(S)** N/A
TASK SUMMARY This step begins once the team leader determines that UTACC has generated an acceptable mission profile from the unit's present position to the objective area. The human selects the approved mission profile via the user interface system. Once a mission profile is approved, UTACC should update the common tactical picture (CTP) with the approved route to the objective area. This step concludes when the CTP has been updated with the approved route.	
REFERENCE DOCUMENTS None	
PLANNING FACTORS	
THREAT ANALYSIS Omitted	
CONDITIONS N/A	
ASSUMPTIONS None	
RESOURCES **1.** Small Tactical Unit Leader **2.** UTACC **a.** User Interface System	
SPECIFIED TASKS None	
IMPLIED TASKS None	
LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R]) None	
SHORTFALLS None	

UTACC ACTIONS
INPUTS Team leader approved mission profile from the unit's present position to the objective.
PROCESS UTACC updates CTP with the team leader approved route.
OUTPUTS Updated CTP.
ASSOCIATED IERs **1.** IER CTP-01, 07, 09, **2.** IER RP-02, 03

J. SUBMIT TO HHQ FOR APPROVAL AND ASSIGNMENT OF SUPPORTING/JOINT ASSETS

TASK NAME Submit to HHQ for Approval and Assignment of Supporting/Joint Assets	**TASK ABBREVIATION** PLNG.CP.HHQ.
CATALOG NUMBER 4.4	**PARENT/ REVIOUS TASK(S)** Select Mission Profile (4.3)
CHILD/SUBSEQUENT TASK(S) Issue Order / Conduct Digital 3D Rehearsals (5.1)	**PARALLEL TASK(S)** N/A
TASK SUMMARY This step begins once a mission profile has been selected by the team leader. Assuming a Common Tactical Picture (CTP) is shared with the small tactical unit's higher headquarters, the CTP will be updated with the team leader approved route. It is possible that this route could conflict with adjacent unit mission profiles. This step is simply a placeholder to illustrate that higher headquarters may dictate a return to previous steps in the 'Complete Plan' swimlane.	
REFERENCE DOCUMENTS None	
PLANNING FACTORS	
THREAT ANALYSIS Omitted	
CONDITIONS N/A	
ASSUMPTIONS The CTP is shared with higher headquarters/adjacent units/joint assets.	
RESOURCES **1.** Small Tactical Unit Leader **2.** UTACC **a.** User Interface System	
SPECIFIED TASKS None	
IMPLIED TASKS None	
LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R]) None	

SHORTFALLS None
UTACC ACTIONS
INPUTS Higher headquarters rejects team leader approved route.
PROCESS UTACC updates the common tactical picture with the route from the unit to the objective area.
OUTPUTS Updated CTP.
ASSOCIATED IERs **1.** IER CTP-01, 07, 09, **2.** IER RP-02, 03

K. ISSUE ORDER AND CONDUCT DIGITAL 3D REHEARSAL(S)

TASK NAME Issue Order and Conduct Digital 3D Rehearsals	**TASK ABBREVIATION** PLNG.IO.ORD
CATALOG NUMBER 5.1	**PARENT/PREVIOUS TASK(S)** Submit to HHQ for Approval and Assignment of Supporting/Joint Assets (4.4)
CHILD / SUBSEQUENT TASK(S) Task Module (Execute Reconnaissance Mission) (T.1)	**PARALLEL TASK(S)** N/A
TASK SUMMARY Once the mission profile has been approved by the team leader, there will be a period of downtime while the team leader prepares the order. UTACC robotic components should use this time for maintenance, refueling, and recharging as this is the last step prior to mission execution. The team leader will prepare the order utilizing the 5 paragraph order format (See Appendix C, IER SB-05 for format of order). Once the order is issued, final preparations before execution include the conduct of rehearsals at the assembly area. Chapter 5 of this thesis discusses possible future work concerning digital 3D rehearsals with simulation software. Since UTACC robotic components conducted the majority of mission planning, it is essential that the small tactical unit become familiar with the plan and the route via rehearsals. Video imagery derived from UAV reconnaissance could be utilized to conduct a virtual walkthrough of the route and the objective area. This is a human intensive phase of the planning process, UTACC components should use this time to ensure final preparations are made (regarding system health) prior to mission execution.	
REFERENCE DOCUMENTS None	
PLANNING FACTORS	
THREAT ANALYSIS Omitted	
CONDITIONS N/A	
ASSUMPTIONS None	
RESOURCES **1.** Small Tactical Unit Leader **2.** UTACC **a.** User Interface System	
SPECIFIED TASKS None	
IMPLIED TASKS None	

LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R]) None
SHORTFALLS None
UTACC ACTIONS
INPUTS Team leader requests sensor data derived from reconnaissance in order to conduct 3d rehearsals.
PROCESS **1.** UTACC delivers sensor data to user interface system. **2.** UTACC conducts final maintenance preparations prior to execution phase.
OUTPUTS None
ASSOCIATED IERs **1.** IER SB-05 **2.** IER CTP-01, 09

L. TASK MODULE (SUBPROCESS)

1. Execute Task

TASK NAME Execute Task (Example for Route Reconnaissance)	**TASK ABBREVIATION** EXE.TM.RR
CATALOG NUMBER T.1	**PARENT / PREVIOUS TASK(S)** Issue Order / Conduct Digital 3D Rehearsals (5.1)
CHILD / SUBSEQUENT TASK(S) Conduct Departure of Friendly Lines (T.1.1)	**PARALLEL TASK(S)** N/A
TASK SUMMARY **This worksheet provides a brief overview of the following mission within the task module, "route reconnaissance."** *Future mission task modules should begin with an overview of the mission, followed by detailed mission dependent steps* (i.e., departure of friendly lines, infiltration, actions on the objective, and re-entry of friendly lines are steps associated with the route reconnaissance mission). [Ref 1] The four forms of ground reconnaissance operations are area reconnaissance, zone reconnaissance, route reconnaissance, and force oriented reconnaissance. Ground reconnaissance missions greatly increase a patrol's vulnerability and chances of compromise. The ground reconnaissance team's mobility is generally limited to foot movement. Therefore, the amount of equipment carried reduces the size of the area they can reconnoiter. [Ref 1] Route reconnaissance is focused along a specific line of communication, such as a road, railway, or waterway, to provide new or updated information on conditions and activities along the route. Additionally, a route reconnaissance will focus on all terrain from which the enemy could influence movement along that route. Considerations include: danger areas, vehicle weight and size limitations (e.g. UxVs), observation along the route, cover and concealment along the route, landing zones along the route, and bridges along the route. [Ref 1]	
REFERENCE DOCUMENTS **1.** MCWP 2–25	
PLANNING FACTORS	
THREAT ANALYSIS Omitted	
CONDITIONS N/A	
ASSUMPTIONS None	

RESOURCES
1. Small Tactical Unit
2. UTACC
    a. User Interface System
    b. Air Carrier
    c. UAV 1
    d. UAV 2
    e. Ground Carrier
    f. UGV 1
    g. UGV 2

SPECIFIED TASKS Based on mission.
IMPLIED TASKS Derived from Mission
LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R]) Derived from Mission
SHORTFALLS Derived from Mission
UTACC ACTIONS
INPUTS Derived from Planning
PROCESS Dynamic; based on mission
OUTPUTS Based on mission
ASSOCIATED IERs Based on mission

2. Conduct Departure of Friendly Lines

TASK NAME Departure of Friendly Lines	**TASK ABBREVIATION** EXE.TM.DOFL
CATALOG NUMBER T.1.1	**PARENT/PREVIOUS TASK(S)** Execute Task (Route Recon) (T.1)
CHILD/SUBSEQUENT TASK(S) Conduct Insertion and Infiltration (T.2)	**PARALLEL TASK(S)** None

TASK SUMMARY

The departure from friendly lines must be thoroughly planned and coordinated.

a. **Coordination.** The small unit leader must coordinate with forward unit(s) (if available) and the leaders of other units that will be patrolling in the same or adjacent areas. The coordination includes: signal plan, fire plan, running password, procedures for departure and reentry lines, dismount points, initial rally points, departure and reentry points, and information about the enemy.

(1) The small unit leader provides the forward unit leader with the unit identification, the size of the patrol, the departure and return times, and the area of operation.

(2) The forward unit leader provides the departing small unit leader with the following:

-Additional information on terrain.
-Known or suspected enemy positions.
-Likely enemy ambush sites.
-Latest enemy activity.
-Detailed information on friendly positions and obstacle locations. This includes the location of OPs.
-Friendly unit fire plan.
-Support that the unit can provide; for example, fire support, litter teams, guides, communications, and reaction force. [Ref 1, 2]

b. **Planning.** In his plan for the departure of friendly lines, the leader should consider the following sequence of actions:

- Making contact with friendly guides at the contact point. (If available: guides would come from a forward unit that is more familiar with the area of operation than the departing unit).
-Moving to the coordinated initial rally point.
-Completing final coordination.
-Moving to and through the passage point.
-Establishing a security-listening halt beyond the friendly unit's final protective fires. [Ref 1, 2]

Initial rally point (IRP) - An initial rally point is a place inside of friendly lines where a unit may assemble and reorganize if it makes enemy contact during the departure of friendly lines or before reaching the first en-route rally point. It is normally selected by the commander of the friendly unit. [Ref 1, 2]

Passage point (PP) - A specifically designated place where units will pass through the line of departure (LD) in an advance or a withdrawal. It is located where the commander desires subordinate units to physically execute a passage of lines. [Ref 1, 2]

Line of departure (LD) - The line of departure (LD) is drawn with reference to the location on the battlefield where enemy contact is possible. Generally this falls before and perpendicular to the route being reconnoitered, allowing adequate space for the unit conducting the reconnaissance to deploy into formation. The LD creates the rear boundary of the AO. [Ref 1, 2]

REFERENCE DOCUMENTS
1. FM 7–8, Chapter 3 **2.** FM 3–90-2, page 1–6
PLANNING FACTORS
THREAT ANALYSIS Omitted
CONDITIONS N/A
ASSUMPTIONS None
RESOURCES **1.** Small Tactical Unit **2.** UTACC **a.** User Interface System **b.** Air Carrier **c.** UAV 1 **d.** UAV 2 **e.** Ground Carrier **f.** UGV 1 **g.** UGV 2
SPECIFIED TASKS Conduct Route Reconnaissance
IMPLIED TASKS **1.** Departure of friendly lines itself is an implied task imbedded under the specified task "Conduct route recon." **2.** Assemble unit at initial rally point. **3.** Establish patrol formation (e.g., wedge, column, echelon, etc.) **4.** Cross the line of departure (LD) at the passage point (PP)
LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R]) None
SHORTFALLS None
UTACC ACTIONS
INPUTS **1.** Raw 3D map info. **2.** Control Measures overlay (LD, IRP, limit of advance (LOA), named areas of interest) **3.** Team leader directed formation **4.** Team leader directed sensor posture

PROCESS Planning for the departure from friendly lines is the last task the small unit will accomplish prior to entering the execution phase. This should be the time when the UxSs run system checks to ensure that they have all required information and resources to execute the mission (e.g., fuel, sensors, situational awareness: all products generated during planning such as the 3d map overlayed with the LD and LOA).
OUTPUTS Beginning of execution phase. Small unit and UGVs cross the LD and UAVs assume designated sensor posture.
ASSOCIATED IERs **1.** IER SB-03, 05, 11 **2.** IER BF-02, 03, 04 **3.** CTP 01, 02, 06, 07 **4.** IER SU-05 **5.** IER RP-12

3. Conduct Insertion and Infiltration

<table>
<tr><td><u>TASK NAME</u>
Conduct Insertion and Infiltration</td><td><u>TASK ABBREVIATION</u>
EXE.TM.I&I</td></tr>
<tr><td><u>CATALOG NUMBER</u>
T.1.2</td><td><u>PARENT/PERVIOUS TASK(S)</u>
Conduct Departure from Friendly Lines (T.1.1)</td></tr>
<tr><td><u>CHILD/SUBSEQUENT TASK(S)</u>
Conduct Actions on the Objective (T.1.3)</td><td><u>PARALLEL TASK(S)</u>
None</td></tr>
<tr><td colspan="2"><u>TASK SUMMARY</u>

The insertion and infiltration phase extends from the point of embarkation to the arrival in the objective area. The unit leader is responsible for supervising the execution of insertions. The leader ensures that prior coordination is done, that adequate alternatives and contingency plans are in place, and that supporting units fully understand and perform their role. [Ref 1]

A variety of insertion methods are utilized by reconnaissance units, however for the purpose of this concept of operations, foot movement is the chosen method of insertion. Generally, the infiltration phase continues with the unit’s movement from the point of insertion to the security halt, and ends before the unit occupies the objective rally point (ORP). Ideally, insertion and infiltration occur during times of limited visibility (to avoid detection). If the unit must halt during periods of increased visibility, they will establish a clandestine patrol base. During infiltration, patrol members record the unit’s movement in their patrol logs. Patrol log details include:
• General direction of movement
• Deviations from planned infiltration route
• Information about terrain and weather; including their effects on friendly and enemy patrols
• Enemy sightings en route
• Signs of activity
• Key grid locations
• Any peculiarities, including map corrections
• Times of key events [Ref 1]

Regarding movement techniques, infiltration is a clandestine activity with the goal being to move as a unit such that detection is unlikely. As a result, it is preferred to move through terrain which people rarely inhabit (densely wooded areas, mountainous countryside) as opposed to roads or paths. This could be problematic for the UGVs and should be considered during design. [Ref 1]

[See task analysis worksheets on formations (F.1 – F.12) regarding specifics on foot movement]</td></tr>
<tr><td colspan="2"><u>REFERENCE DOCUMENTS</u>
1. MCWP 2–25 (DRAFT)</td></tr>
<tr><td colspan="2">PLANNING FACTORS</td></tr>
<tr><td colspan="2"><u>THREAT ANALYSIS</u>
Omitted</td></tr>
</table>

CONDITIONS **1.** Limited visibility (darkness, fog) **2.** Terrain which offers cover and concealment **3.** Terrain which reduces the noise signature of the unit (e.g., wet leaves, snow)
ASSUMPTIONS None
RESOURCES **1.** Small Tactical Unit **2.** UTACC **a.** User Interface System **b.** Air Carrier **c.** UAV 1 **d.** UAV 2 **e.** Ground Carrier **f.** UGV 1 **g.** UGV 2
SPECIFIED TASKS Conduct route reconnaissance
IMPLIED TASKS Infiltration is implied under the specified task listed above.
LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R]) **[C]** Proceed from point of insertion / friendly lines to the ORP
SHORTFALLS None
UTACC ACTIONS
INPUTS **1.** Raw 3D map info with route of infiltration overlay **2.** Parameters for movement (e.g., operating envelope) **3.** Team leader chosen formation for movement **4.** Location of objective rally point **5.** Obstacles identified on MCOO during planning (M.2) **6.** Team leader designated sensor posture for infiltration
PROCESS Because infiltration is likely conducted during periods of darkness and through somewhat restrictive terrain, UGVs must be capable of operating in these conditions. Ground sensors can be utilized to assist team members with navigation and force protection during movement. Air sensors can be utilized for force protection, as well as surveillance of the ORP and the objective. The noise signature of the UxSs is an important consideration regarding insertion and infiltration.
OUTPUTS Patrol log report (listed above)

<u>ASSOCIATED IERs</u>

1. IER SB-02, 03, 05, 10, 11
2. IER BF-03
3. IER CTP-01, 02, 05, 06, 07, 08, 09, 10
4. IER SU-04
5. IER RP-02, 03, 05, 07, 12

4. Conduct Actions on the Objective

TASK NAME Conduct Actions on the Objective	TASK ABBREVIATION EXE.TM.AOBJ
CATALOG NUMBER T.1.3	**PARENT/PREVIOUS TASK(S)** Conduct Insertion and Infiltration (T.1.2)
CHILD TASK(S) Conduct Re-entry of Friendly Lines (T.1.4)	**PARALLEL TASK(S)** N/A

TASK SUMMARY

There are two primary activities which are essential upon the small unit's arrival at the objective area. The first is to establish an objective rally point (see definition below) in order to establish observation of the objective while still maintaining stealth and security. The second is to begin communicating to higher headquarters or an operations center in order to report priority information that is required for intelligence purposes. In addition to surveillance, UAVs could fill a critical role as a communications relay during actions on the objective.

The ground reconnaissance patrol establishes a security halt and the leader reconnoiters to identify an objective rally point (ORP). After the unit establishes the ORP, the leader moves out to pinpoint the objective or named area of interest and locate a tentative observation post (OP). Once the leader's reconnaissance is complete, the patrol will move to and establish a hide site, gaining communications with the recon operations center (ROC). The team will establish an observation post and will maintain "eyes on" the objective and maintain continuous communications with the hide site. The observation post generates intelligence reports and relays them to the hide site. The hide site sends information to the ROC via HF or UHF tactical satellite (TACSAT) communications. If the ground reconnaissance patrol cannot establish communications, it and the ROC will execute the "no communications" contingency plan that was developed during the planning phase. The ground reconnaissance patrol will continue to collect information and send reports to the ROC until the patrol meets the mission completion criteria. The reconnaissance patrol reports during designated communication windows or, if the report is information answering a priority information request (PIR), out of those windows with FLASH traffic. After the patrol withdrawals from the objective they disseminate information, collect all OP logs, and objective sketches. [Ref 1]

Additional information regarding the ORP is found in chapter 3 or Ref 2.

REFERENCE DOCUMENTS

1. MCWP 2–25 (DRAFT)
2. FM 7–8, Chapter 3

PLANNING FACTORS

THREAT ANALYSIS
Omitted

CONDITIONS
N/A

ASSUMPTIONS
None

RESOURCES

1. Small Tactical Unit
2. UTACC
   a. User Interface System
   b. Air Carrier
   c. UAV 1
   d. UAV 2
   e. Ground Carrier
   f. UGV 1
   g. UGV 2

SPECIFIED TASKS

Conduct Ground Reconnaissance of OBJ 'XX'

IMPLIED TASKS

Conduct actions on the objective is implied under the specified task listed above.

LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R])

[R] Compromise the location of the ORP (noise, movement, etc.)
[R] Engage the enemy except as a result of self defense

SHORTFALLS

None

UTACC ACTIONS

INPUTS

1. Raw 3D map info.
2. Location of team leader designated ORP
3. Location of objective
4. Parameters for movement (e.g., operating envelope)

PROCESS

The UxSs can be utilized for a variety of purposes regarding actions on the objective. For the reconnaissance mission, sensors can enable increased standoff for the small infantry unit reducing the risk of compromising the location of the ORP. This could be particularly helpful in sparse terrain where cover is difficult to find. The UAVs, in addition to providing eyes on the objective, would be useful as a communications relay to report PIRs to the operations center.

OUTPUTS

1. Detailed imagery of the objective.
2. Priority intelligence reported to the operations center.

ASSOCIATED IERs

1. IER SB-02, 07, 08
2. IER CTP-03, 09
3. IER SU-02, 03
4. IER RP-02, 05, 07, 14

5. Conduct Re-entry of Friendly Lines

TASK NAME Conduct Re-entry of Friendly Lines	**TASK ABBREVIATION** EXE.TM.REOFL
CATALOG NUMBER T.1.4	**PARENT/PREVIOUS TASK(S)** Conduct Actions on the Objective (T.1.3)
CHILD/SUBSEQUENT TASK(S) None	**PARALLEL TASK(S)** None

TASK SUMMARY

The small unit leader's initial planning and coordination must include the reentry of friendly lines. Reentry of friendly lines at night is dangerous and should only be attempted when it is essential to the success of the patrol. [Ref 1]

a. The unit halts in the reentry rally point (RRP) and establishes security.
b. The unit leader radios the code word advising the friendly unit of its location and that it is ready to return. The friendly unit must acknowledge the message and confirm that guides are waiting before the unit moves from the RRP.
c. Once the friendly unit acknowledges the return of the unit, the unit leader issues a five-point contingency plan and moves with his radio operator and a two-man (buddy team) security element on a determined azimuth and pace to the reentry point.
d. The unit leader uses far and near recognition signals to establish contact with the guide.
e. The unit leader signals the unit forward (radio) or returns and leads it to the reentry point. He may post the security element with the guide at the enemy side of the reentry point.
f. The unit sergeant counts and identifies each Marine as he passes through the reentry point.
g. The guide leads the unit to the assembly area.
h. The unit leader reports to the command post of the friendly unit. He tells the commander everything of tactical value concerning the friendly unit's area of responsibility.
i. The unit leader rejoins the unit in the assembly area and leads it to a secure area for debriefing. [Ref 1]

Reentry rally point. The reentry rally point is located out of sight, sound, and small-arms weapons range of the friendly unit through which the unit will return. This also means that the RRP should be outside the final protective fires of the friendly unit. The unit occupies the RRP as a security perimeter. [Ref 1]

REFERENCE DOCUMENTS

1. FM 7–8, Chapter 3

PLANNING FACTORS

THREAT ANALYSIS

Omitted

CONDITIONS

1. Daylight
2. Clear visibility

ASSUMPTIONS

None

RESOURCES **1.** Small Tactical Unit **2.** UTACC **a.** User Interface System **b.** Air Carrier **c.** UAV 1 **d.** UAV 2 **e.** Ground Carrier **f.** UGV 1 **g.** UGV 2
SPECIFIED TASKS Conduct route reconnaissance
IMPLIED TASKS Re-entry of friendly lines is implied under the specified task above at the conclusion of the mission.
LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R]) **[R]** Attempt Re-entry during periods of darkness (except by necessity) **[R]** Move parallel to friendly lines within visual or small arms range of friendly line.
SHORTFALLS None
UTACC ACTIONS
INPUTS **1.** Location of OPs **2.** Location of RRP
PROCESS Fairly self-explanatory procedure intended to prevent fratricide. The UGVs could potentially be used as the lead elements for re-entry in case of mistaken identity. Implementing some form of transponder on the UxSs could allow returning units to be *interrogated* prior to re-entry as an additional measure to prevent fratricide.
OUTPUTS None
ASSOCIATED IERs **1.** IER SB-03, 12 **2.** IER BF-03 **3.** IER CTP-02, 10

M. SENSOR POSTURE (SUBPROCESS)

1. Select Sensor Posture

TASK NAME Select Sensor Posture	**TASK ABBREVIATION** EXE.SP.SSP
CATALOG NUMBER S.1	**PARENT/PREVIOUS TASK(S)** None
CHILD/SUBSEQUENT TASK(S) Neutral Sensor Posture (S.1.1) Offensive Sensor Posture (S.1.2) Defensive Sensor Posture (S.1.3)	**PARALLEL TASK(S)** None
TASK SUMMARY The aerial sensor posture describes how the UAVs utilize their sensors in support of the ground scheme of maneuver. The unit leader selects from three possible sensor postures based on mission specific factors.	
REFERENCE DOCUMENTS **1.** MCWP 3–26 **2.** MCWP 3–42.1	
PLANNING FACTORS	
THREAT ANALYSIS Omitted	
CONDITIONS **1.** Daytime **2.** Visibility – Good 3–10 nmi [Ref 2, C 1.3.2]	
ASSUMPTIONS None	
RESOURCES **1.** UTACC **a.** UAV 1 **b.** UAV 2 Note 1:Two sensors (one on each UAV). Both sensors should, at a minimum, meet or exceed the resolution capability of the AN/AAQ-28(V) LITENING Targeting Pod. Note 2: One sensor must also be capable of generating 1cm resolution mapping and high quality coordinates. Further capabilities may be required based on future research.	
SPECIFIED TASKS Conduct Defensive, Neutral, or Offensive Sensor Posture in support of the ground scheme of maneuver.	
IMPLIED TASKS None	

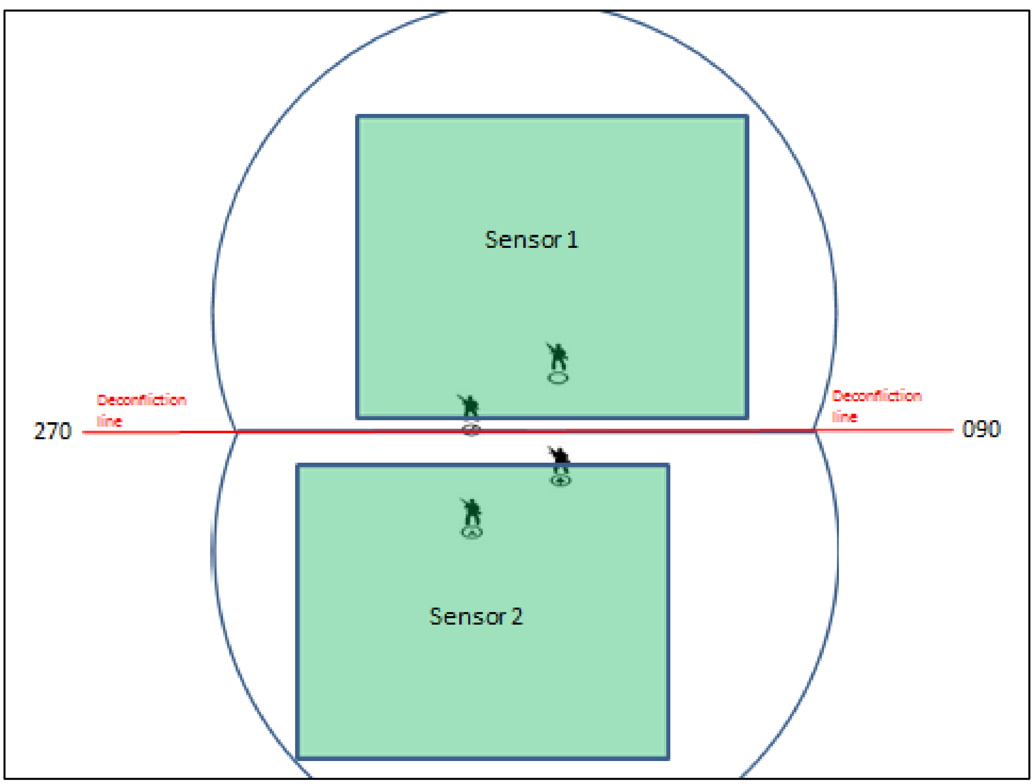
LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R]) **[C]** UAV(s) must fly within the designated airspace structure.
SHORTFALLS None
UTACC ACTIONS
INPUTS **1.** Raw 3D map info. **2.** Approved mission profile graphic. **3.** Input from fireteam to assume NSP, OSP, or DSP (DSP default in absence of guidance).
PROCESS The UAV(s) utilize the COA graphic and 3D map information to determine applicable avenues of approach, friendly positioning and direction of movement, and information about the objective in order to establish initial positioning of sensors for DSP, OSP, or NSP.
OUTPUTS **1.** Alert Updates (Simulated RFID of enemy, Navigation, System status, ETC) **2.** (For example) 3D map update that makes route unpassable for UTACC ground systems. **3.** 3D map with 1cm resolution. **4.** High quality coordinates. **5.** On demand Sensor data to team member(s) display. **6.** On demand location and identification information for enemy, team members and UTACC components.
ASSOCIATED IER(s) **1.** IER SB-05, 11, 12 **2.** IER BF-02, 03, 04 **3.** IER CTP-01, 05, 08, 09 **4.** IER SU-05

2. Defensive Sensor Posture

TASK NAME	**TASK ABBREVIATION**
Defensive Sensor Posture	EXE.SP.DSP
CATALOG NUMBER S.1.1	**PARENT/PREVIOUS TASK(S)** Select Sensor Posture (S.1)
CHILD/SUBSEQUENT TASK(S) Degraded Sensor Posture (S.2)	**PARALLEL TASK(S)** Neutral Sensor Posture (S.1.2) Offensive Sensor Posture (S.1.3)

TASK SUMMARY

The Defensive Sensor Posture (DSP) is primarily used when the small tactical unit leader requires maximum sensor coverage of a friendly position such as in the defense or when moving in a highly uncertain and/or hostile environment. The Defensive Sensor Posture should be considered the "default" sensor posture as it requires no additional information from the team leader to execute. The DSP should be assumed by the UAVs in the absence of further guidance from the team leader. As depicted below, both UAVs should orient sensors on the friendly position. The UAVs should be able to deconflict the two sensors scans to allow for 360 degrees of coverage around the friendly position. For example, sensor 1 covers the North sector while sensor 2 covers the South sector. Due to the fact that there are 2 sensors covering the entire 360 degrees, the sensors can afford to scan further away from the friendly position (out to approximately 2 km) in each designated scan sector, further increasing the situational awareness of the small tactical unit.



REFERENCE DOCUMENTS
1. MCWP 3–26
2. MCWP 3–42.1

PLANNING FACTORS

THREAT ANALYSIS
Omitted

CONDITIONS
1. Daytime
2. Visibility – Good 3–10 nmi [Ref 2, C 1.3.2]

ASSUMPTIONS
None

RESOURCES
1. UTACC
    a. UAV 1
    b. UAV 2

    Note 1: Two sensors (one on each UAV). Both sensors should, at a minimum, meet or exceed the resolution capability of the AN/AAQ-28(V) LITENING Targeting Pod.

SPECIFIED TASKS
Conduct Defensive Sensor Posture.

IMPLIED TASKS
1. UAVs should deconflict sensor scan sectors based on the situation. The default deconfliction plan could be as simple as North/South. This may need to change depending on the situation. For example, a river or major line of communication could be a more logical way of dividing the sensor scan between the two sensors. Also, the terrain may require much more time to scan one sector than the other, requiring something other than a 50/50 breakup of scan sectors.
2. Sensors should provide on demand updates to CTP regarding enemy location and identification information.

LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R])
[C] UAVs will fly within structure of designated airspace.

SHORTFALLS
None

UTACC ACTIONS

INPUTS
1. UTACC generated 3D map
2. Team leader gives command (either hand and arm or voice) for UTACC to assume DSP.
3. Team leader provides additional guidance to UAV regarding required information.
4. Optional adjustment to sensor posture.

PROCESS **1.** UAVs determine best scan sectors for sensor deconfliction based on terrain / mission considerations. **2.** UAS sensors scan their respective sectors for threat activity. **3.** UAS references critical information requirements.
OUTPUTS **1.** Alert Updates (Simulated RFID of enemy, Navigation, System status, ETC) **2.** (For example) 3D map update that makes route unpassable for UTACC ground systems. **3.** On demand Sensor data to team member(s) display. **4.** On demand location and identification information for Enemy, team members and UTACC components.
ASSOCIATED IER(s) **1.** IER SB-05, 11, 12 **2.** IER BF-02, 03, 04 **3.** IER CTP-01, 05, 08, 09 **4.** IER SU-05

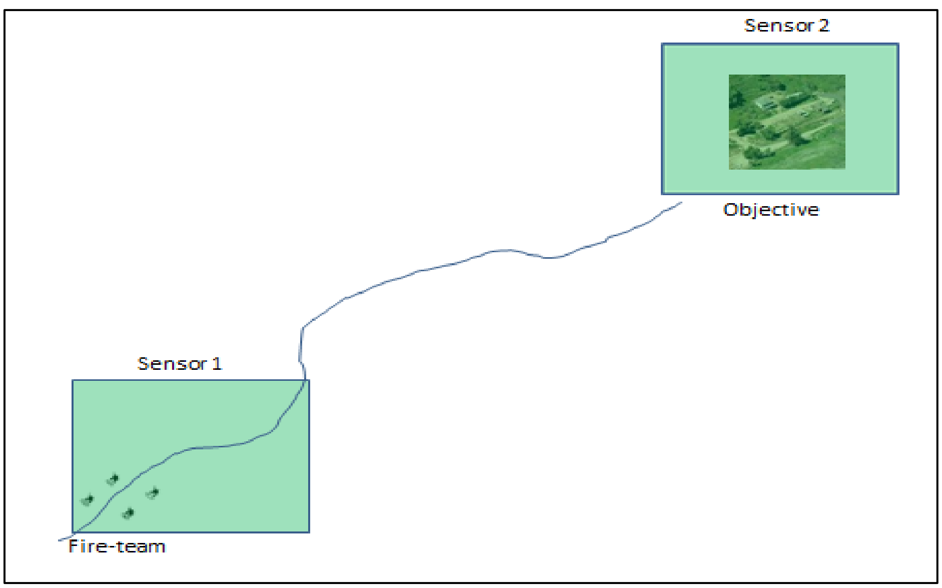
3. Neutral Sensor Posture

TASK NAME Neutral Sensor Posture	**TASK ABBREVIATION** EXE.SP.NSP
CATALOG NUMBER S.1.2	**PARENT/PREVIOUS TASK(S)** Select Sensor Posture (S.1)
CHILD/SUBSEQUENT TASK(S) Degraded Sensor Posture (S.2)	**PARALLEL TASK(S)** Offensive Sensor Posture (S.1.3) Defensive Sensor Posture (S.1.1)

TASK SUMMARY

The neutral sensor posture (NSP) means that the UAVs maintain one sensor on the small tactical unit, while the other sensor stays focused on the objective (or destination of movement). This posture allows for a compromise between security and intelligence gathering of the objective area. The sensor focused on the small tactical unit should not focus exclusively on the team members through a "soda straw," but should scan up to 1 kilometer in all directions in order to provide security updates to the team. As a rule of thumb, 75 percent of scan time should be biased in the direction of the team's movement while the remaining 25 percent should scan the flanks and the rear. Additionally, the sensor focused on the team should keep track of all team members and be capable of providing on demand location and identification information to the Common Tactical Picture (CTP).

To execute the NSP, there must be another sensor focused primarily on the objective. Similar to the first sensor, it should scan in and around the objective. It should provide on demand updates to team regarding personnel, vehicles, obstacles, avenues of approach, etc.



REFERENCE DOCUMENTS
1. MCWP 3–26
2. MCWP 3–42.1

PLANNING FACTORS

THREAT ANALYSIS
Omitted

CONDITIONS
1. Daytime
2. Visibility – Good 3–10 nmi [Ref 2, C 1.3.2]

ASSUMPTIONS
None

RESOURCES
1. UTACC
   a. UAV 1
   b. UAV 2

   Note 1: Two sensors (one per UAV). The neutral sensor posture is currently executed adequately with modern EO/IR sensors. Sensors should, at a minimum, meet or exceed the resolution capability of the AN/AAQ-28(V) LITENING Targeting Pod.

SPECIFIED TASKS
Conduct Neutral Sensor Posture.

IMPLIED TASKS
1. Both sensors should actively scan in and around their assigned areas and provide on demand updates regarding personnel, vehicles, obstacles, avenues of approach, etc.
2. Sensor oriented on friendlies should bias scan pattern forward of friendlies, spending 75 percent of search time scanning in the direction of friendly movement while the remaining 25 percent should scan the flanks and the rear.
3. Sensor oriented on friendlies should provide on demand updates to COP regarding personnel location and identification information.

LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R])
[C] UAVs will fly within structure of designated airspace.

SHORTFALLS
None

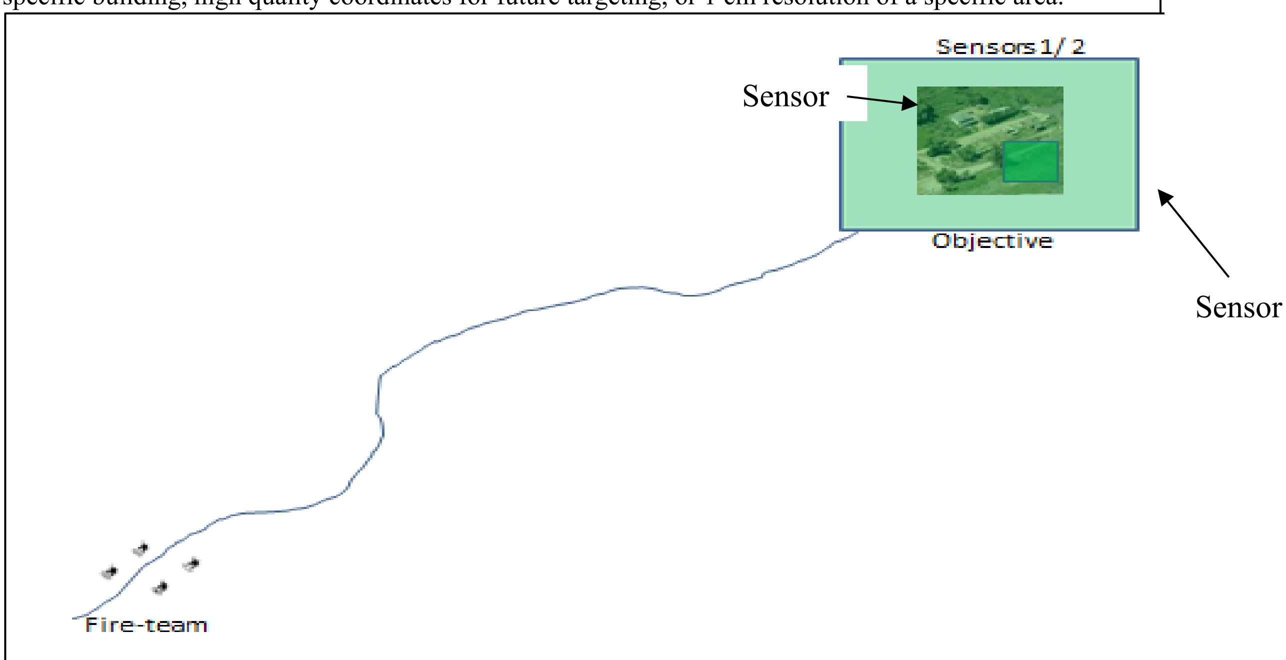
UTACC ACTIONS
INPUTS **1.** UTACC generated 3D map **2.** Team leader gives command for the small tactical unit to move in a specified direction. **3.** Team leader designated objective. **4.** Team leader provides additional guidance to UAVs regarding additional information requirements. **5.** Optional adjustment to sensor posture.
PROCESS **1.** UAV 1 establishes overwatch of the small tactical unit, biasing its scan pattern forward of the unit in their direction of movement. **2.** UAV 2 focuses its scan on the Objective. **3.** UAVs continuously assess personnel, avenues of approach, obstacles, and IR Significant areas. **4.** UAVs references critical information requirements.
OUTPUTS **1.** Alert Updates (Simulated RFID of enemy, Navigation, System status, ETC) **2.** (For example) 3D map update that makes route unpassable for UTACC ground systems. **3.** On demand Sensor data to team member(s) display. **4.** On demand location and identification information for enemy, team members and UTACC components.
ASSOCIATED IERs **1.** IER SB-05, 11, 12 **2.** IER BF-02, 03, 04 **3.** IER CTP-01, 05, 08, 09 **4.** IER SU-05

4. Offensive Sensor Posture

TASK NAME Offensive Sensor Posture	**TASK ABBREVIATION** EXE.SP.OSP
CATALOG NUMBER S.1.3	**PARENT/PREVIOUS TASK(S)** Select Sensor Posture (S.1)
CHILD /SUBSEQUENT TASK(S) Degraded Sensor Posture (S.2)	**PARALLEL TASK(S)** Neutral Sensor Posture (S.1.2) Defensive Sensor Posture (S.1.1)

TASK SUMMARY

The Offensive Sensor Posture (OSP) is primarily used when actions on the objective are imminent and the team leader wants maximum coverage and intelligence regarding the objective. UTACC must be directed to assume the OSP since it prevents any sensors from providing security to the small tactical unit. Upon receiving order from the team leader, both sensors will focus their scans on the objective. As depicted below, one sensor will continue to scan as in the neutral sensor posture, while the other could develop more detailed information about the objective. For example: the team leader may require a detailed scan of a specific building, high quality coordinates for future targeting, or 1 cm resolution of a specific area.



REFERENCE DOCUMENTS

1. MCWP 3–26
2. MCWP 3–42.1

PLANNING FACTORS
THREAT ANALYSIS Omitted
CONDITIONS **1.** Daytime **2.** Visibility – Good 3–10 nmi [Ref 2, C 1.3.2]
ASSUMPTIONS None
RESOURCES **1.** UTACC **a.** UAV 1 **b.** UAV 2 Note 1: Both sensors (one on each UAV). Both sensors should, at a minimum, meet or exceed the resolution capability of the AN/AAQ-28(V) LITENING Targeting Pod. Note 2: One sensor must also be capable of generating 1cm resolution mapping and high quality coordinates. Further capabilities may be required based on future research.
SPECIFIED TASKS Conduct Offensive Sensor Posture.
IMPLIED TASKS **1.** Provide persistent, detailed surveillance of Objective A. **2.** UAV 1 should actively scan in and around the Objective area and provide on demand updates regarding personnel, vehicles, obstacles, avenues of approach, etc. **3.** UAV 2 should, situationally dependent, be capable of providing more detailed intelligence of Objective such as 1cm resolution or high quality coordinates. **4.** Sensors should provide on demand updates to CTP regarding enemy location and identification information.
LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R]) **[C]** UAVs will fly within structure of designated airspace.
SHORTFALLS None
UTACC ACTIONS
INPUTS **1.** UTACC generated 3D map **2.** Team leader designates Objective. **3.** Team leader gives command (either hand and arm or voice) for UTACC to assume OSP. **4.** Team leader provides guidance to UAVs regarding required detailed information. **5.** Optional adjustment (from team leader) to sensor postures.

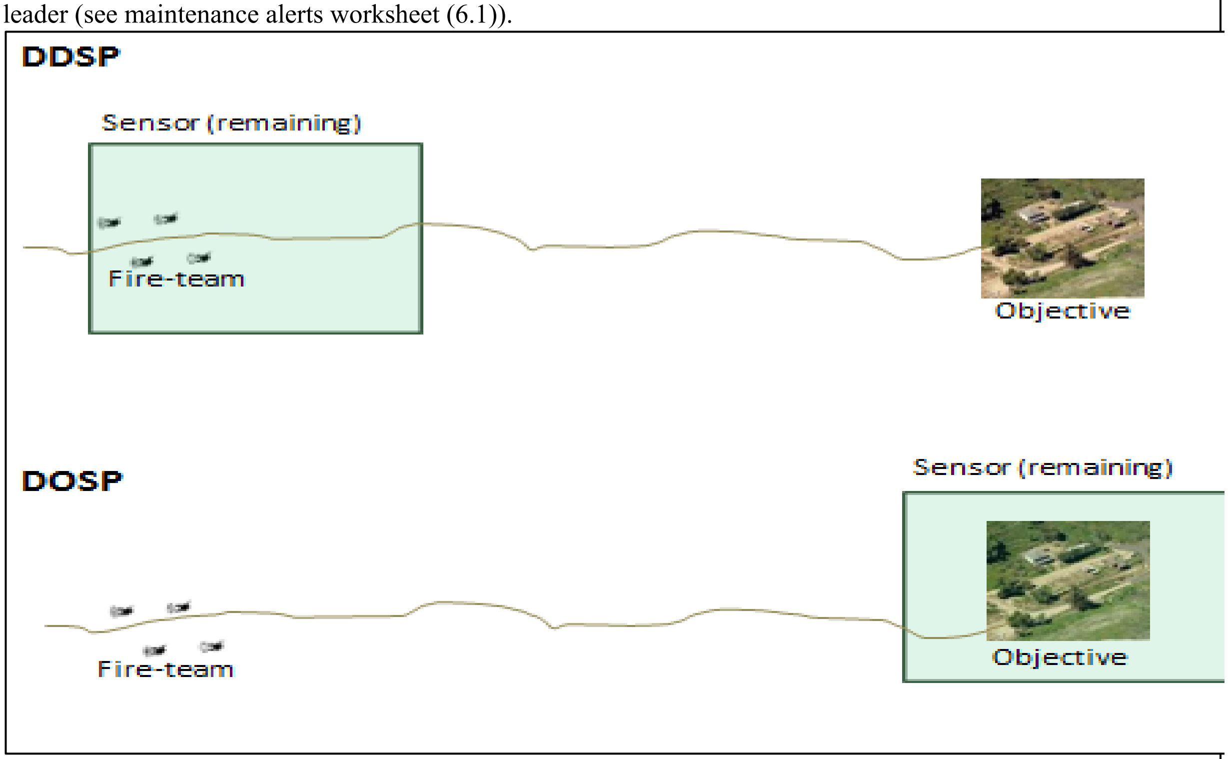
PROCESS **1.** UAV 1 focuses its scan on the Objective, continuously assessing personnel, avenues of approach, obstacles, and IR significant areas. **2.** UAV 2, depending on input from team leader, gathers detailed information about Objective. **3.** UAVs references critical information requirements.
OUTPUTS **1.** Alert Updates (Simulated RFID of enemy, Navigation, System status, ETC) **2.** (For example) 3D map update that makes route unpassable for UTACC ground systems. **3.** 3D map with 1cm resolution. **4.** High quality coordinates. **5.** On demand Sensor data to team member(s) display. **6.** On demand location and identification information for Enemy, team members and UTACC components.
ASSOCIATED IER(s) **1.** IER SB-05, 11, 12 **2.** IER BF-02, 03, 04 **3.** IER CTP-01, 05, 08, 09 **4.** IER SU-05

5. Degraded Sensor Posture

TASK NAME Degraded Sensor Posture	**TASK ABBREVIATION** EXE.SP.DEGSP
CATALOG NUMBER S.2	**PARENT/PREVIOUS TASK(S)** Neutral Sensor Posture (S.1.2) Offensive Sensor Posture (S.1.3) Defensive Sensor Posture (S.1.1)
CHILD/SUBSEQUENT TASK(S) None	**PARALLEL TASK(S)** None

TASK SUMMARY

The degraded sensor postures are used when UTACC only has one aerial surveillance sensor available for employment. In this case, UTACC must either use that sensor for overwatch of the small tactical unit (degraded defensive sensor posture), or for ISR of the objective area (degraded offensive sensor posture). As depicted below, DOSP would be used when actions on the objective are imminent and the team leader wants maximum coverage and intelligence regarding the objective. DDSP is used when the ground unit wants maximum sensor coverage of a friendly position such as in the defense or when moving in a highly uncertain and/or hostile environment. If a sensor is lost while executing the defensive or offensive sensor postures, the remaining sensor will continue to execute the degraded defensive/offensive sensor posture. If a sensor is lost executing the neutral sensor posture, UTACC should default to DDSP and keep providing ISR of the friendlies unless directed by the team leader to transition to DOSP. Additionally, the UAV should provide a PMC maintenance alert to the team leader (see maintenance alerts worksheet (6.1)).



REFERENCE DOCUMENTS
1. MCWP 3–26
2. MCWP 3–42.1

PLANNING FACTORS

THREAT ANALYSIS
Omitted

CONDITIONS
1. Daytime
2. Visibility – Good 3–10 nmi [Ref 2, C 1.3.2]

ASSUMPTIONS
None.

RESOURCES
1. UTACC
    a. UAV 1

        Note 1: One sensor capable of providing ISR with resolution equal to or greater than modern targeting pods.

SPECIFIED TASKS
Conduct Degraded Defensive or Offensive Sensor Posture.

IMPLIED TASKS
1. If a sensor is lost while executing OSP, UTACC components automatically assume DOSP.
2. If a sensor is lost while executing DSP, UTACC components automatically assume DDSP.
3. If a sensor is lost while executing NSP, UTACC components automatically assume DDSP.
4. Remaining sensor should actively scan in and around the assigned area and provide on demand updates regarding personnel, vehicles, obstacles, avenues of approach, etc.
5. Sensors should provide on demand updates to COP regarding enemy location and identification information.

LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R])
[C] UAVs will fly within structure of designated airspace.

SHORTFALLS
None

UTACC ACTIONS

INPUTS
1. UTACC generated 3D map
2. Team leader designates Objective.
3. UTACC recognizes the loss of a sensor.
4. Optional adjustment (from team leader) to sensor postures.

PROCESS The remaining sensor will continue to scan its original area if a sensor is lost from the defensive or offensive sensor posture. If sensor is lost from the neutral sensor posture, the remaining sensor should scan in and around the friendly position immediately. Scan technique remains unchanged from the other sensor posture worksheets except that the remaining sensor may have to scan a larger area.
OUTPUTS **1.** Alert / Cue updates (Simulated RFID of enemy, Navigation, System status, etc.) **2.** High quality coordinates. **3.** On demand Sensor data to team member display. **4.** On demand location and identification information for enemy, team members and UTACC components. **5.** PMC or NMC maintenance alert broadcast throughout UTACC (see maintenance alerts worksheet).
ASSOCIATED IER(s) **1.** IER SB-05, 11, 12 **2.** IER BF-02, 03, 04 **3.** IER CTP-01, 05, 08, 09 **4.** IER SU-05

N. MAINTENANCE ALERTS

TASK NAME Maintenance Alerts	**TASK ABBREVIATION** EXE.MA
CATALOG NUMBER 6.1	**PARENT/PREVIOUS TASK(S)** N/A
CHILD/SUBSEQUENT TASK(S) N/A	**PARALLEL TASK(S)** Task Module Subprocess Sensor Posture Subprocess Formations Subprocess Maintain COP Subprocess Tactical Alerts and Cueing Subprocess

TASK SUMMARY

UTACC components should periodically perform built-in-tests of critical sub-components (sensors, avionics, engine components, etc.). Sub-Components should be grouped based on how critical the component is in executing a task. These groups are labeled fully-mission capable (FMC), partially-mission capable (PMC) and non-mission capable (NMC).

FMC:
When testing multiple sub-components within UTACC, minor faults and degrades will likely be discovered which do not affect the performance of UTACC in support of a task. These failed components belong in the "FMC" category and need not be communicated to anyone. The results of the failed tests should simply be saved for download next time the component returns for maintenance. [Ref 1]

PMC:
PMC failures are failures which result in UTACC operating in a degraded mode. For example, the loss of the 3d mapping capability while it still retains the ability to perform standard surveillance. This failure would need to be communicated, via a CUE (no human input required) to the team leader through the primary user interface device. Since these failures are not as serious as NMC failures, recommend color coding these alerts (orange for PMC, red for NMC). [Ref 1]

NMC:
Failures which restrict a UTACC component from operating and/or performing the assigned mission. This could be either the loss of all sensors, or the critical failure of a major sub-component such as the engine, flight control system, etc. NMC failures must be presented immediately to the team leader, via an ALERT, through the user interface system (recommend red color). [Ref 1]

While not specifically a maintenance issue, fuel states will be an additionally "component health" issue that could be presented using the preceding metric. A PMC alert could be issued when a component has 15 (or 20, or 30) minutes time on station before needing to return for fuel. A NMC alert would then be issued as the component checks off station, notifying the team that this component is no longer available.

REFERENCE DOCUMENTS

1. COMNAVAIRFORINST 4790.2B, CH. 17 (Subsystem capability and impact reporting)

PLANNING FACTORS
THREAT ANALYSIS Omitted
CONDITIONS N/A
ASSUMPTIONS None
RESOURCES **1.** UTACC **a.** User Interface System **b.** Air Carrier **c.** UAV 1 **d.** UAV 2 **e.** Ground Carrier **f.** UGV 1 **g.** UGV 2
SPECIFIED TASKS Any task that has been given the command to execute. Built in testing and reporting is a continuous behavior that UTACC components should perform whenever they are operational.
IMPLIED TASKS None
LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R]) **[C]** There are situations when a component could be rendered NMC prior to having an opportunity to report this information (hits an IED and instantly is destroyed). The other components need to realize that this component is now missing (components routinely “ping” each other?). The NMC alert would then be communicated to the fireteam by one of the other UTACC components.
SHORTFALLS None
UTACC ACTIONS
INPUTS Built-in-test results from all sub-components within UTACC.
PROCESS When a sub-system is found to have failed or is degraded, the component must reference some sort of matrix regarding which alert to trigger. For example, the loss of the laser used for 3d mapping could render the component NMC if the assigned task is to return with a 3d map. If the assigned task is wide area surveillance, this would be a PMC loss. There are certain losses that will be universal (task independent). For example, the UAV always needs an engine, rotor blades, fuel, and a flight control system to operate.
OUTPUTS Color coded alerts to user interface regarding sub-system health of UTACC components.
ASSOCIATED IERs **1.** IER-BF-02

O. FORMATIONS (SUBPROCESS)

1. Machine-Only Formations

a. Balanced

TASK NAME UGVs Balanced Formation	**TASK ABBREVIATION** EXE.FORM.MACH.BAL
CATALOG NUMBER F.1	**PARENT/PREVIOUS TASK(S)** Select Formation
CHILD/SUBSEQUENT TASK(S) None	**PARALLEL TASK(S)** All other Formations (F.2-F.12)
TASK SUMMARY UTACC system moves to designated location. Air, Ground Carriers and UGVs maintain maximum dispersion while maintaining stealth and speed of movement as mission dictates. UGVs will move freely around Carriers to provide increased sensor data to UTACC.	
REFERENCE DOCUMENTS None	
PLANNING FACTORS	
THREAT ANALYSIS Omitted	
CONDITIONS Terrain that supports UGV operations	
ASSUMPTIONS None	
RESOURCES **1.** UTACC **a.** User Interface System **b.** Air Carrier **c.** UAV 1 **d.** UAV 2 **e.** Ground Carrier **f.** UGV 1 **g.** UGV 2	
SPECIFIED TASKS Conduct UTACC movement to designated location in balanced formation.	
IMPLIED TASKS Provide real-time surveillance to support small tactical unit.	

LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R]) None
SHORTFALLS None
UTACC ACTIONS
INPUTS **1.** UTACC generated 3D map **2.** Team leader designates location to move to. **3.** Team leader designates UGV deployment.
PROCESS UTACC takes inputs and produces a route to follow to the designated location. The Small Unit Leader can approve the route, or provides additional inputs and UTACC produces a revised new route
OUTPUTS **1.** Refined 3D map **2.** Alert Updates (Enemy, Navigation, UTACC status, etc) **3.** On demand Sensor data to Small Tactical Unit member display. **4.** On demand location and identification information for Enemy, Small Tactical Unit members and UTACC components.
ASSOCIATED IER(s) **1.** IER SB-11 **2.** IER BF-03 **3.** IER CTP-02, 07 **4.** IER RP-05

b. Forward Focused

TASK NAME UGVs Forward of Formation	**TASK ABBREVIATION** EXE.FORM.MAC.FOR
CATALOG NUMBER F.2	**PARENT/PREVIOUS TASK(S)** Select Formation
CHILD/SUBSEQUENT TASK(S) None	**PARALLEL TASK(S)** All other Formations (F.1) & (F.3-F.12)
TASK SUMMARY UTACC system moves to designated location. Air, Ground Carriers and UGVs maintain maximum dispersion while maintaining stealth and speed of movement as mission dictates. Both UGVs will be deployed to front of Carriers maintaining uniform distance to the carriers providing increased sensor input to UTACC.	
REFERENCE DOCUMENTS None	
PLANNING FACTORS	
THREAT ANALYSIS Omitted	
CONDITIONS Terrain that supports UGV operations	
ASSUMPTIONS None	
RESOURCES **1.** UTACC **h.** User Interface System **a.** Air Carrier **b.** UAV 1 **c.** UAV 2 **d.** Ground Carrier **e.** UGV 1 **f.** UGV 2	
SPECIFIED TASKS Conduct UTACC movement to designated location.	
IMPLIED TASKS Provide realtime surveillance to support Small Tactical Unit.	
LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R]) None	
SHORTFALLS None	

UTACC ACTIONS
INPUTS **1.** UTACC generated 3D map **2.** Small Tactical Unit leader designates location to move to. **3.** Small Tactical Unit leader designates UGV deployment.
PROCESS UTACC takes inputs and produces a route to follow to the designated location. The Small Tactical Unit leader can approve the route, or provides additional inputs and UTACC produces a revised new route
OUTPUTS **1.** Refined 3D map **2.** Alert Updates (Enemy, Navigation, UTACC status, etc) **3.** On demand Sensor data to Small Tactical Unit member display. **4.** On demand location and identification information for Enemy, Small Tactical Unit members and UTACC components.
ASSOCIATED IER(s) **1.** IER SB-11 **2.** IER BF-03 **3.** IER CTP-02, 07 **4.** IER RP-05

c. Rear Focused

TASK NAME UGVs to Rear Formation	**TASK ABBREVIATION** EXE.FORM.MAC.REAR
CATALOG NUMBER F.3	**PARENT/PREVIOUS TASK(S)** Select Formation
CHILD/SUBSEQUENT TASK(S) None	**PARALLEL TASK(S)** All other formations (F.1, F.2) & (F.4-F-12)
TASK SUMMARY UTACC system moves to designated location. Air, Ground Carriers and UGVs maintain maximum dispersion while maintaining stealth and speed of movement as mission dictates. Both UGVs will be deployed to rear of Carriers maintaining uniform distance to the carriers providing increased sensor input to UTACC.	
REFERENCE DOCUMENTS None	
PLANNING FACTORS	
THREAT ANALYSIS Omitted	
CONDITIONS Terrain that supports UGV operations	
ASSUMPTIONS None	
RESOURCES **1.** UTACC **g.** User Interface System **h.** Air Carrier **a.** UAV 1 **b.** UAV 2 **c.** Ground Carrier **d.** UGV 1 **e.** UGV 2	
SPECIFIED TASKS Conduct UTACC movement to designated location.	
IMPLIED TASKS Provide realtime surveillance to support small tactical Marine unit.	
LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R]) None	
SHORTFALLS None	

UTACC ACTIONS
INPUTS **1.** UTACC generated 3D map **2.** Team leader designates location to move to. **3.** Team leader designates UGV deployment.
PROCESS UTACC takes inputs and produces a route to follow to the designated location. The Small Tactical Unit leader can approve the route, or provides additional inputs and UTACC produces a revised new route
OUTPUTS **1.** Refined 3D map **2.** Alert Updates (Enemy, Navigation, UTACC status, etc) **3.** On demand Sensor data to team member display. **4.** On demand location and identification information for Enemy, team members and UTACC components.
ASSOCIATED IER(s) **1.** IER SB-11 **2.** IER BF-03 **3.** IER CTP-02, 07 **4.** IER RP-05

d. Side Focused

TASK NAME UGVs to Side Formation	**TASK ABBREVIATION** EXE.FORM.MAC.SIDE
CATALOG NUMBER F.4	**PARENT/PREVIOUS TASK(S)** Select Formation
CHILD/SUBSEQUENT TASK(S) None	**PARALLEL TASK(S)** All other formations (F.1-F.3) & (F.5-F.12)
TASK SUMMARY UTACC system moves to designated location. Air and Ground Carriers maintain maximum dispersion while maintaining stealth and speed of movement as mission dictates. UGVs will be deployed to the left or right (as designated) side of Carriers and move parallel to the carriers providing increased sensor input to UTACC.	
REFERENCE DOCUMENTS None	
PLANNING FACTORS	
THREAT ANALYSIS Omitted	
CONDITIONS Terrain that supports UGV operations	
ASSUMPTIONS None	
RESOURCES **1.** UTACC **f.** Human Interface System **a.** Air Carrier **b.** UAV 1 **c.** UAV 2 **d.** Ground Carrier **e.** UGV 1 **f.** UGV 2	
SPECIFIED TASKS Conduct UTACC movement to designated location.	
IMPLIED TASKS Provide realtime surveillance to support small tactical Marine unit.	
LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R]) None	
SHORTFALLS None	

UTACC ACTIONS
INPUTS **1.** UTACC generated 3D map **2.** Team leader designates location to move to. **3.** Team leader designates UGV deployment.
PROCESS UTACC takes inputs and produces a route to follow to the designated location. The team leader can approve the route, or provides additional inputs and UTACC produces a revised new route
OUTPUTS **1.** Refined 3D map **2.** Alert Updates (Enemy, Navigation, UTACC status, etc) **3.** On demand Sensor data to team member display. **4.** On demand location and identification information for Enemy, team members and UTACC components.
ASSOCIATED IER(s) **1.** IER SB-11 **2.** IER BF-03 **3.** IER CTP-02, 07 **4.** IER RP-05

2. Human-Only Formations

a. Column

TASK NAME	**TASK ABBREVIATION**
Fireteam Column Formation	EXE.FORM.HUM.COL
CATALOG NUMBER F.5	**PARENT/PREVIOUS TASK(S)** Select Formation
CHILD/SUBSEQUENT TASK(S) None	**PARALLEL TASK(S)** All other Formations (F.1-F.4) & (F.6-F.12).

TASK SUMMARY

Basic fireteam formation that: Permits rapid, controlled movement, favors fire and maneuver to the flanks, but is vulnerable to fire from the front and provides the least amount of fire to the front . [Ref 1, Chap 3]

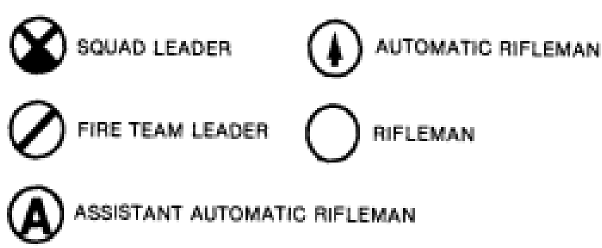


Figure 1-1. Marine Rifle Squad.

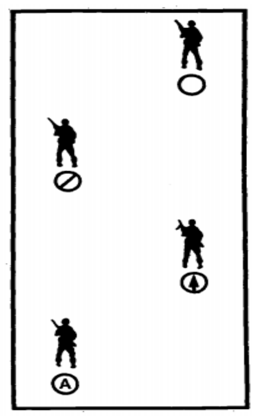
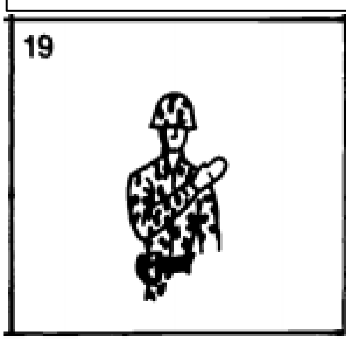


Figure 3-1. Fire Team Column.



All graphics from Ref 1.
Diagram 19 represents Fireteam Signal.
Diagram 10 represents Column Command (Raise either arm to the vertical position. Drop the arm to the rear, describing complete circles in a vertical plane parallel to the body).

REFERENCE DOCUMENTS

1. MCWP 3–11.2 w/ ch1
2. MCO 3500.26

PLANNING FACTORS
THREAT ANALYSIS Omitted
CONDITIONS N/A
ASSUMPTIONS None
RESOURCES **1.** Resources organic to Marine Fireteam. [Ref 1, Chap 1] **a.** Fire Team Leader/Grenadier. M-16 rifle with a 40 mm, M-203 grenade launcher attached and bayonet. **b.** Automatic Rifleman. Infantry Automatic Rifle (IAR) and bayonet. **c.** Assistant Automatic Rifleman. M-16 rifle and bayonet. **d.** Rifleman. M-16 rifle and bayonet. **2.** Supplementary Weapons and Munitions as required [Ref 1, Chap 1] **a.** Demolitions. **b.** Claymore mines. **c.** Hand grenades (fragmentation, smoke, and gas). **d.** Light assault weapons. **e.** Ground signals and flares. **f.** Communications equipment.
SPECIFIED TASKS Assume Fireteam Column movement in designated direction
IMPLIED TASKS **1.** The relative position of the fire teams within the squad formation should be such that one will not mask the fire of the others. [Ref 1, Chap 3] **2.** It is not important that exact distances and intervals be maintained between fire teams and individuals as long as control is not lost. [Ref 1, Chap 3] **3.** Sight or voice contact will be maintained within the fire team and between fire team leaders and squad leaders. [Ref 1, Chap 3] **4.** All movement incident to changes of formation is usually by the shortest practical route. [Ref 1, Chap 3]
LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R]) None
SHORTFALLS None
UTACC ACTIONS
INPUTS N/A
PROCESS N/A
OUTPUTS N/A
ASSOCIATED IER(s) N/A

b. Echelon

TASK NAME Fireteam Echelon Formation	**TASK ABBREVIATION** EXE.FORM.HUM.ECH
CATALOG NUMBER F.6	**PARENT/PREVIOUS TASK(S)** Select Formation
CHILD/SUBSEQUENT TASK(S) None	**PARALLEL TASK(S)** All other Formations (F.1-F.5) & (F.7-F.12)

TASK SUMMARY

Basic fireteam formation that: provides heavy firepower to front and echeloned flank, and is used to protect an open or exposed flank. [Ref 1, Chap 3]

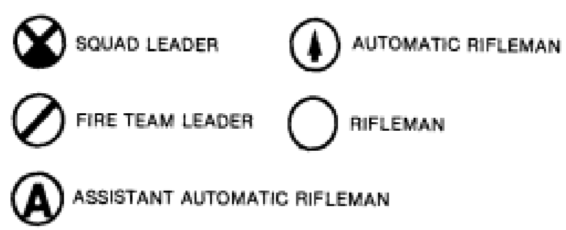


Figure 1-1. Marine Rifle Squad.

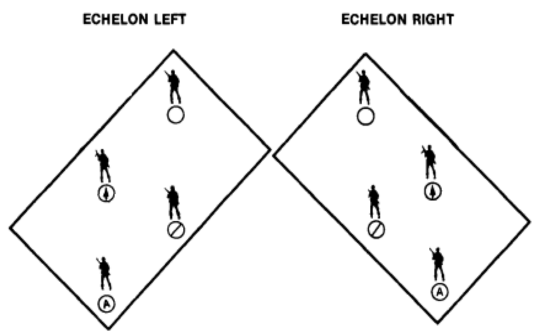
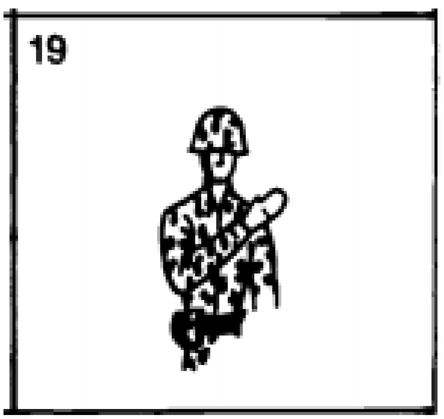
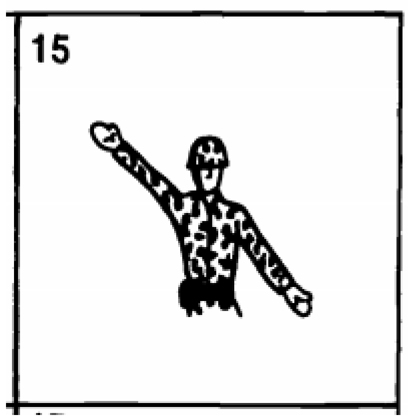


Figure 3-4. Fire Team Echelon.





All graphics from Ref 1.
Diagram 19 represents Fireteam Signal.
Diagram 15 represents Echelon Left Command (The mirror image is Echelon Right; lower arm as seen from behind is the echelon direction).

REFERENCE DOCUMENTS

1. MCWP 3–11.2 w/ ch1
2. MCO 3500.26

PLANNING FACTORS

THREAT ANALYSIS
Omitted

CONDITIONS
N/A

ASSUMPTIONS
None

RESOURCES

1. Resources organic to Marine Fireteam. [Ref 1, Chap 1]
   a. Fire Team Leader/Grenadier. M-16 rifle with a 40 mm, M-203 grenade launcher attached and bayonet.
   b. Automatic Rifleman. Infantry Automatic Rifle (IAR) and bayonet.
   c. Assistant Automatic Rifleman. M-16 rifle and bayonet.
   d. Rifleman. M-16 rifle and bayonet.
2. Supplementary Weapons and Munitions as required [Ref 1, Chap 1]
   a. Demolitions.
   b. Claymore mines.
   c. Hand grenades (fragmentation, smoke, and gas).
   d. Light assault weapons.
   e. Ground signals and flares.
   f. Communications equipment.

SPECIFIED TASKS
Assume Fireteam Echelon (L/R) movement along designated route to Objective A.

IMPLIED TASKS

1. The relative position of the fire teams within the squad formation should be such that one will not mask the fire of the others. [Ref 1, Chap 3]
2. It is not important that exact distances and intervals be maintained between fire teams and individuals as long as control is not lost. [Ref 1, Chap 3]
3. Sight or voice contact will be maintained within the fire team and between fire team leaders and squad leaders. [Ref 1, Chap 3]
4. All movement incident to changes of formation is usually by the shortest practical route. [Ref 1, Chap 3]

LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R])
None

SHORTFALLS
None

UTACC ACTIONS

INPUTS
N/A

PROCESS
N/A

OUTPUTS
N/A

ASSOCIATED IER(s)
N/A

c. Wedge

TASK NAME Fireteam Wedge Formation	**TASK ABBREVIATION** EXE.FORM.HUM.WED
CATALOG NUMBER F.7	**PARENT/PREVIOUS TASK(S)** Select Formation
CHILD/SUBSEQUENT TASK(S) None	**PARALLEL TASK(S)** All other Formations (F.1-F.6) & (F.8-F.12)

TASK SUMMARY

Basic formation that: permits good control, provides all-round security, provides flexibility and allows adequate fire in all directions. [Ref 1, Chap 3]

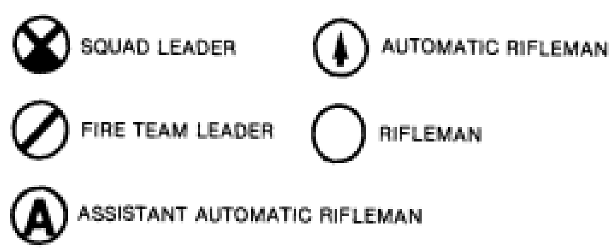
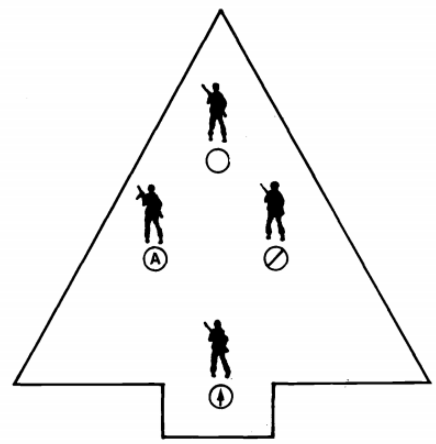
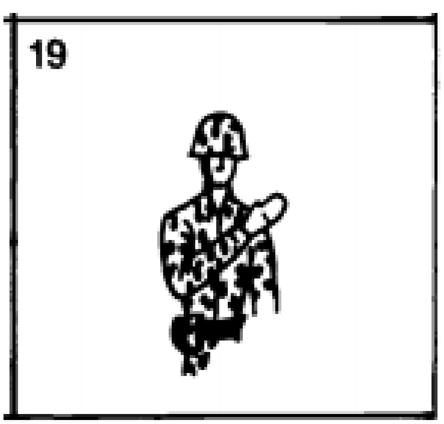


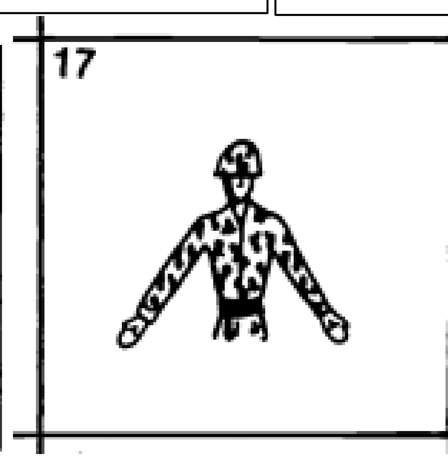
Figure 1-1. Marine Rifle Squad.



NOTE: THE POSITION OF THE FIRE TEAM LEADER AND ASSISTANT AUTOMATIC RIFLEMAN ARE INTERCHANGEABLE.

Figure 3-2. Fire Team Wedge.





All graphics from Ref 1.
Diagram 19 represents Fireteam Signal.
Diagram 17 represents Wedge Command.

REFERENCE DOCUMENTS

1. MCWP 3–11.2 w/ ch1
2. MCO 3500.26

PLANNING FACTORS

THREAT ANALYSIS
Omitted

CONDITIONS
N/A

ASSUMPTIONS
None

RESOURCES

1. Resources organic to Marine Fireteam. [Ref 1, Chap 1]
   - **a.** Fire Team Leader/Grenadier. M-16 rifle with a 40 mm, M-203 grenade launcher attached and bayonet.
   - **b.** Automatic Rifleman. Infantry Automatic Rifle (IAR) and bayonet.
   - **c.** Assistant Automatic Rifleman. M-16 rifle and bayonet.
   - **d.** Rifleman. M-16 rifle and bayonet.

2. Supplementary Weapons and Munitions as required [Ref 1, Chap 1]
   - **a.** Demolitions.
   - **b.** Claymore mines.
   - **c.** Hand grenades (fragmentation, smoke, and gas).
   - **d.** Light assault weapons.
   - **e.** Ground signals and flares.
   - **f.** Communications equipment.

SPECIFIED TASKS
Assume Fireteam Wedge movement in designated direction

IMPLIED TASKS

1. The relative position of the fire teams within the squad formation should be such that one will not mask the fire of the others. [Ref 1, Chap 3]
2. It is not important that exact distances and intervals be maintained between fire teams and individuals as long as control is not lost. [Ref 1, Chap 3]
3. Sight or voice contact will be maintained within the fire team and between fire team leaders and squad leaders. [Ref 1, Chap 3]
4. All movement incident to changes of formation is usually by the shortest practical route. [Ref 1, Chap 3]

LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R])
None

SHORTFALLS
None

UTACC ACTIONS

INPUTS
N/A

PROCESS
N/A

OUTPUTS
N/A

ASSOCIATED IER(s)
N/A

d. Skirmishers

TASK NAME	**TASK ABBREVIATION**
Fireteam Skirmishes Formation	EXE.FORM.HUM.SKR
CATALOG NUMBER F.8	**PARENT/PREVIOUS TASK(S)** Select Formation
CHILD/SUBSEQUENT TASK(S) None	**PARALLEL TASK(S)** All other Formations (F.1-F.7) & (F.9-F.12)

TASK SUMMARY

Basic formation that: provides maximum firepower to the front, and is used when the location and strength of the enemy are known, during the assault, mopping up, and crossing short open areas [Ref 1, Chap 3]

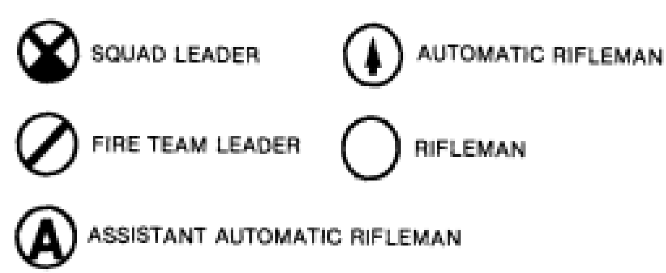


Figure 1-1. Marine Rifle Squad.

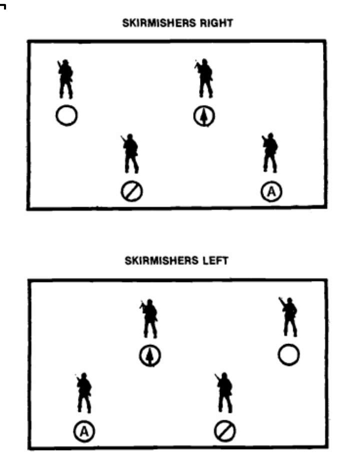
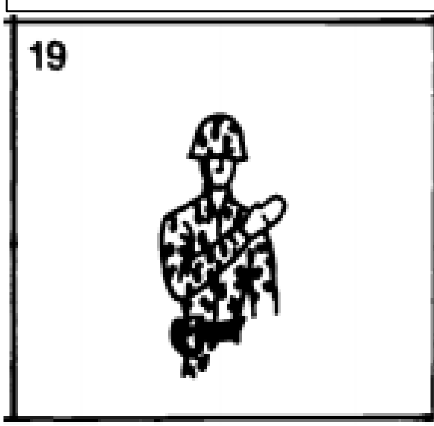
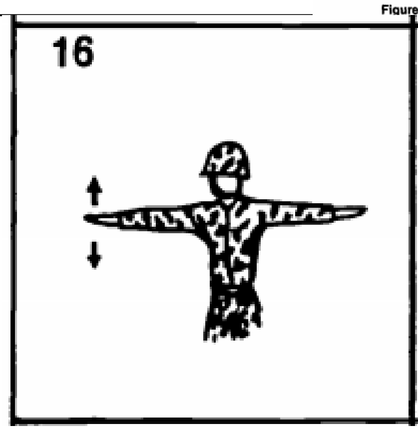


Figure 3-3. Fire Team Skirmishers.





All graphics from Ref 1.
Diagram 19 represents Fireteam Signal.
Diagram 16 represents represents Skirmishes Right Command (The mirror image is Skirmishes Left; Hand moving up and down signals Right or Left).

REFERENCE DOCUMENTS
1. MCWP 3–11.2 w/ ch1
2. MCO 3500.26

PLANNING FACTORS

THREAT ANALYSIS
Omitted

CONDITIONS
N/A

ASSUMPTIONS
None

RESOURCES
1. Resources organic to Marine Fireteam. [Ref 1, Chap 1]
    a. Fire Team Leader/Grenadier. M-16 rifle with a 40 mm, M-203 grenade launcher attached and bayonet.
    b. Automatic Rifleman. Infantry Automatic Rifle (IAR) and bayonet.
    c. Assistant Automatic Rifleman. M-16 rifle and bayonet.
    d. Rifleman. M-16 rifle and bayonet.
2. Supplementary Weapons and Munitions as required [Ref 1, Chap 1]
    a. Demolitions.
    b. Claymore mines.
    c. Hand grenades (fragmentation, smoke, and gas).
    d. Light assault weapons.
    e. Ground signals and flares.
    f. Communications equipment.

SPECIFIED TASKS
Assume Fireteam Skirmishes movement in designated direction

IMPLIED TASKS
1. The relative position of the fire teams within the squad formation should be such that one will not mask the fire of the others. [Ref 1, Chap 3]
2. It is not important that exact distances and intervals be maintained between fire teams and individuals as long as control is not lost. [Ref 1, Chap 3]
3. Sight or voice contact will be maintained within the fire team and between fire team leaders and squad leaders. [Ref 1, Chap 3]
4. All movement incident to changes of formation is usually by the shortest practical route. [Ref 1, Chap 3]

LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R])
None

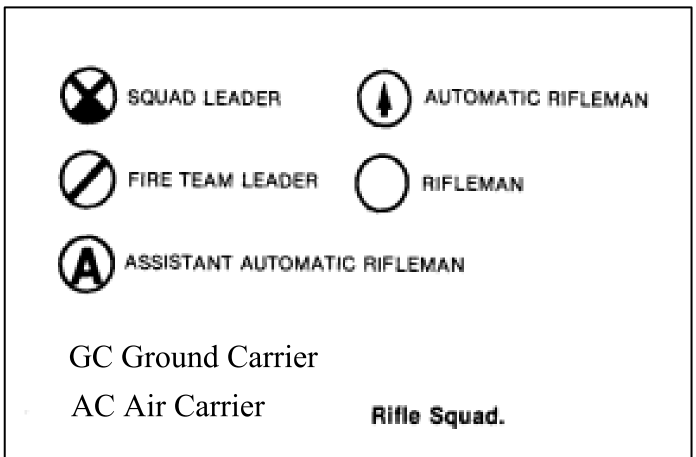
SHORTFALLS
None

UTACC ACTIONS
INPUTS N/A
PROCESS N/A
OUTPUTS N/A
ASSOCIATED IER(s) N/A

3. Combined Formations

a. Column

<table>
<tr><td><u>TASK NAME</u>
Fireteam Column Formation With UTACC</td><td><u>TASK ABBREVIATION</u>
Exec.Form.Com.Col</td></tr>
<tr><td><u>CATALOG NUMBER</u>
F.9</td><td><u>PARENT/PREVIOUS TASK(S)</u>
Select Formation</td></tr>
<tr><td><u>CHILD/SUBSEQUENT TASK(S)</u>
None</td><td><u>PARALLEL TASK(S)</u>
All other Formations (F.1-F.8) & (F.10-F.12)</td></tr>
<tr><td colspan="2"><u>TASK SUMMARY</u>
Human Component- Basic fireteam formation that: Permits rapid, controlled movement, favors fire and maneuver to the flanks, but is vulnerable to fire from the front and provides the least amount of fire to the front . [Ref 1, Chap 3]
Machine Component- UTACC assets provide Sensor information to Fireteam



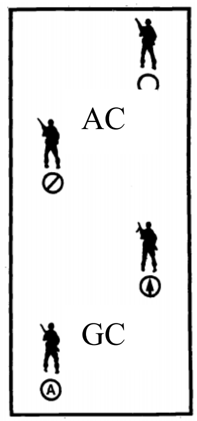
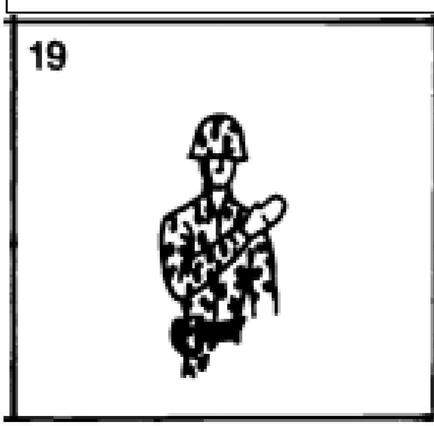
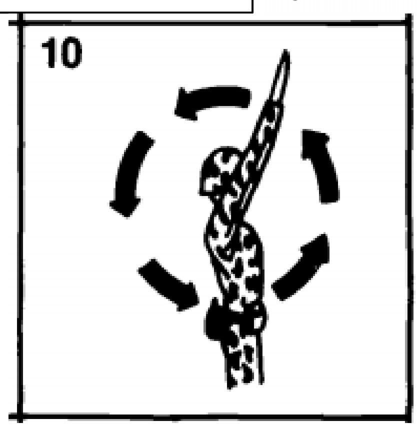


Figure 3-1. Fire Team Column.





Graphics derived from Ref 1.
Diagram 19 represents Fireteam Signal.
Diagram 10 represents Column Command (Raise either arm to the vertical position. Drop the arm to the rear, describing complete circles in a vertical plane parallel to the body).</td></tr>
</table>

REFERENCE DOCUMENTS
1. MCWP 3–11.2 w/ ch1
2. MCO 3500.26

PLANNING FACTORS

THREAT ANALYSIS
Omitted

CONDITIONS
N/A

ASSUMPTIONS
None

RESOURCES
1. Small Tactical Unit
2. UTACC
    a. User Interface System
    b. Air Carrier
    c. UAV 1
    d. UAV 2
    e. Ground Carrier
    f. UGV 1
    g. UGV 2

SPECIFIED TASKS
Assume Column movement in designated direction.

IMPLIED TASKS
1. The relative position of the fire teams within the squad formation should be such that one will not mask the fire of the others. [Ref 1, Chap 3]
2. It is not important that exact distances and intervals be maintained between fire teams and individuals as long as control is not lost. [Ref 1, Chap 3]
3. Sight or voice contact will be maintained within the fire team and between fire team leaders and squad leaders. [Ref 1, Chap 3]
4. All movement incident to changes of formation is usually by the shortest practical route. [Ref 1, Chap 3]

LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R])
None

SHORTFALLS
None

UTACC ACTIONS
INPUTS **1.** UTACC generated 3D map **2.** Fireteam leader give hand and arm signal for wedge formation. **3.** Fireteam leader designates direction of movement **4.** Fireteam leader provides optional adjustment to initial positions of Carrier (Air, Ground). **5.** Initial sensor employment of Carrier (Air, Ground). **6.** Optional employment options for UGVs
PROCESS Air Carrier establishes its initial position between Rifleman and Fireteam Leader Ground Carrier establishes its initial position between Automatic Riflemen and Assistant Automatic Riflemen.
OUTPUTS **1.** Refined 3D map **2.** Alert Updates (Enemy, Navigation, System status, ETC) **3.** (For example) 3D map update that makes route unpassable for UTACC ground systems. **4.** On demand Sensor data to Fireteam member display. **5.** On demand location and identification information for Enemy, fireteam members and UTACC components.
ASSOCIATED IER(s) **1.** IER SB-11 **2.** IER BF-03 **3.** IER CTP-02, 07 **4.** IER RP-05

b. Echelon

TASK NAME Fireteam Echelon Formation With UTACC	**TASK ABBREVIATION** EXE.FORM.COM.ECH
CATALOG NUMBER F.10	**PARENT/PREVIOUS TASK(S)** Select Formation
CHILD/SUBSEQUENT TASK(S) None	**PARALLEL TASK(S)** All other Formations (F.1-F.9) & (F.11-F.12)

TASK SUMMARY

Human Component- Basic fireteam formation that: provides heavy firepower to front and echeloned flank, and is used to protect an open or exposed flank. [Ref 1, Chap 3]

Machine Component- UTACC assets provide Sensor information to team leader.

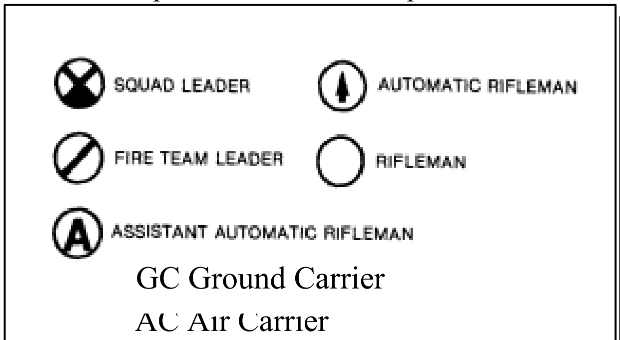


Figure 1-1. Marine Rifle Squad.

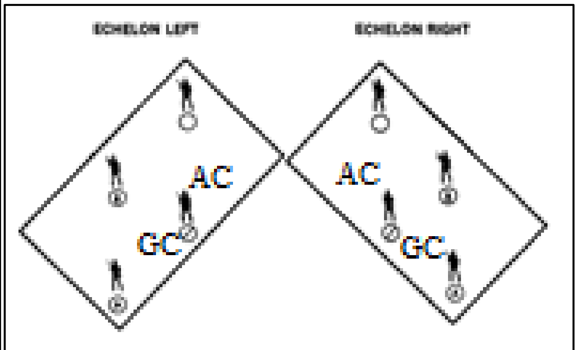
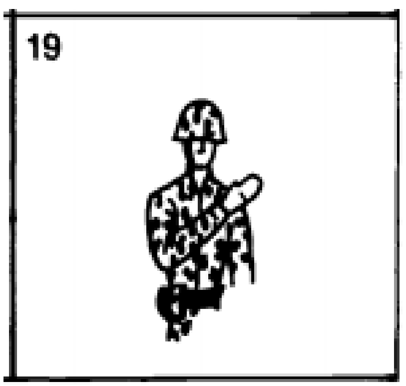
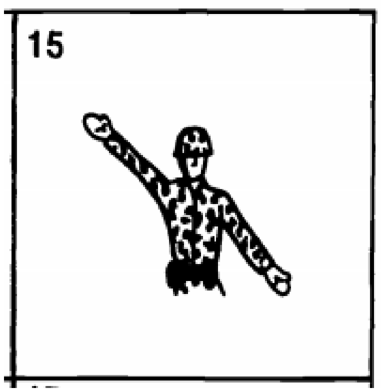


Figure 3-4. Fire Team Echelon.





Graphics derived from Ref 1.

Diagram 19 represents Fireteam Signal.

Diagram 15 represents Echelon Left Command (The mirror image is Echelon Right; lower arm as seen from behind is the echelon direction).

REFERENCE DOCUMENTS

1. MCWP 3–11.2 w/ ch1

2. MCO 3500.26

PLANNING FACTORS

THREAT ANALYSIS
Omitted

CONDITIONS
N/A

ASSUMPTIONS
None

RESOURCES
1. Small Tactical Unit
2. UTACC
    a. User Interface System
    b. Air Carrier
    c. UAV 1
    d. UAV 2
    e. Ground Carrier
    f. UGV 1
    g. UGV 2

SPECIFIED TASKS
Conduct Fireteam Echelon (L/R) movement in designated direction.

IMPLIED TASKS
1. Provide persistent surveillance to support team movement.
2. The relative position of the fire teams within the squad formation should be such that one will not mask the fire of the others. [Ref 1, Chap 3]
3. It is not important that exact distances and intervals be maintained between fire teams and individuals as long as control is not lost. [Ref 1, Chap 3]
4. Sight or voice contact will be maintained within the fire team and between fire team leaders and squad leaders. [Ref 1, Chap 3]
5. All movement incident to changes of formation is usually by the shortest practical route. [Ref 1, Chap 3]

LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R])
None

SHORTFALLS
None

UTACC ACTIONS

INPUTS
1. UTACC generated 3D map
2. team leader give hand and arm signal for Echelon formation.
3. team leader designates direction of movement
4. team leader provides optional adjustment to initial positions of Carrier (Air, Ground).
5. Initial sensor employment of Carrier (Air, Ground).
6. Optional employment options for UGVs

PROCESS Air Carrier establishes its initial position in line between the Riflemen and team leader Ground Carrier establishes its initial position in line between the Automatic Riflemen and Assistant Automatic Riflemen
OUTPUTS **1.** Refined 3D map **2.** Alert Updates (Enemy, Navigation, System status, ETC) **3.** (For example) 3D map update that makes route unpassable for UTACC ground systems. **4.** On demand Sensor data to Fireteam member display. **5.** On demand location and identification information for Enemy, fireteam members and UTACC components.
ASSOCIATED IER(s) **1.** IER SB-11 **2.** IER BF-03 **3.** IER CTP-02, 07 **4.** IER RP-05

c. Wedge

TASK NAME	**TASK ABBREVIATION**
Fireteam Wedge Formation With UTACC	EXE.FORM.COM.WED
CATALOG NUMBER F.11	**PARENT/PREVIOUS TASK(S)** Select Formation
CHILD/SUBSEQUENT TASK(S) None	**PARALLEL TASK(S)** All other Formations (F.1-F.10) & (F12)

TASK SUMMARY

Human Component- Basic formation that: permits good control, provides all-round security, provides flexibility and allows adequate fire in all directions. [Ref 1, Chap 3]
Machine Component- UTACC assets provide Sensor information to small tactical Marine unit.

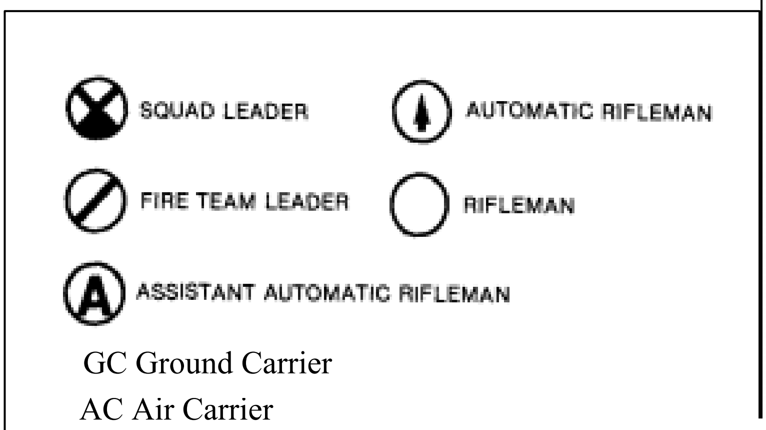


Figure 1-1. Marine Rifle Squad.

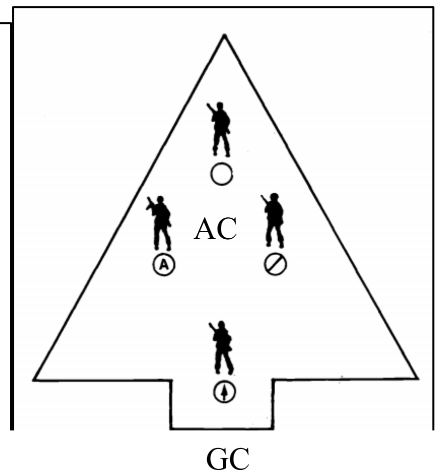
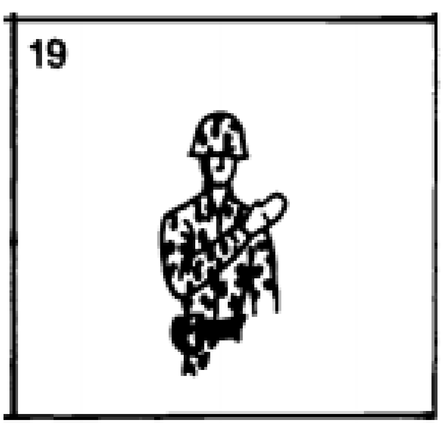
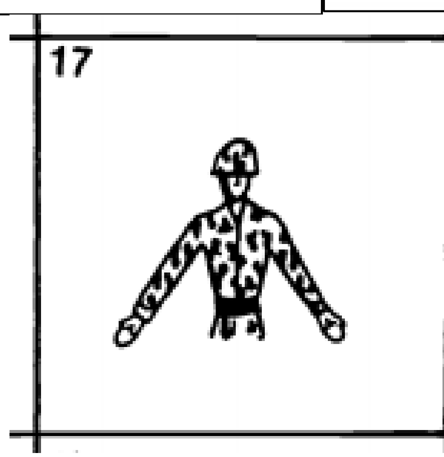


Figure 3-2. Fire Team Wedge.





Graphics derived Ref 1.
Diagram 19 represents Fireteam Signal.
Diagram 17 represents Wedge Command.

REFERENCE DOCUMENTS

1. MCWP 3–11.2 w/ ch1
2. MCO 3500.26

PLANNING FACTORS

THREAT ANALYSIS
Omitted

CONDITIONS
N/A

ASSUMPTIONS
None

RESOURCES
1. Small Tactical Unit
2. UTACC
   a. Human Interface System
   b. Air Carrier
   c. UAV 1
   d. UAV 2
   e. Ground Carrier
   f. UGV 1
   g. UGV 2

SPECIFIED TASKS
1. Conduct Fireteam Wedge movement in designated direction.
2. Provide persistent surveillance to support Fireteam movement.

IMPLIED TASKS
1. The relative position of the fire teams within the squad formation should be such that one will not mask the fire of the others. [Ref 1, Chap 3]
2. It is not important that exact distances and intervals be maintained between fire teams and individuals as long as control is not lost. [Ref 1, Chap 3]
3. Sight or voice contact will be maintained within the fire team and between fire team leaders and squad leaders. [Ref 1, Chap 3]
4. All movement incident to changes of formation is usually by the shortest practical route. [Ref 1, Chap 3]

LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R])
None

SHORTFALLS
None

SYSTEM ACTIONS

SYSTEM INPUTS
1. UTACC generated 3D map
2. Fireteam leader give hand and arm signal for wedge formation.
3. team leader designates direction of movement
4. team leader provides optional adjustment to initial positions of Carrier (Air, Ground).
5. Initial sensor employment of Carrier (Air, Ground).
6. Optional employment options for UGVs

SYSTEM PROCESS Air Carrier establishes its initial position in the center of the team formation Ground Carrier establishes its initial position 50 meters to the rear of the Fireteam.
SYSTEM OUTPUTS **1.** Refined 3D map **2.** Alert Updates (Enemy, Navigation, System status, ETC) **3.** (For example) 3D map update that makes route unpassable for UTACC ground systems. **4.** On demand Sensor data to Fireteam member display. **5.** On demand location and identification information for Enemy, fireteam members and UTACC components.
ASSOCIATED IER(S) **1.** IER SB-11 **2.** IER BF-03 **3.** IER CTP-02, 07 **4.** IER RP-05

d. Skirmishers

TASK NAME	**TASK ABBREVIATION**
Fireteam Skirmishes Formation With UTACC	EXE.FORM.COM.SKR
CATALOG NUMBER F.12	**PARENT/PREVIOUS TASK(S)** Select Formation
CHILD/SUBSEQUENT TASK(S) None	**PARALLEL TASK(S)** All other Formations (F.1-F.11)

TASK SUMMARY

Human Component- Basic formation that: provides maximum firepower to the front, and is used when the location and strength of the enemy are known, during the assault, mopping up, and crossing short open areas [Ref 1, Chap 3]

Machine Component- UTACC assets provide Sensor information to Fireteam

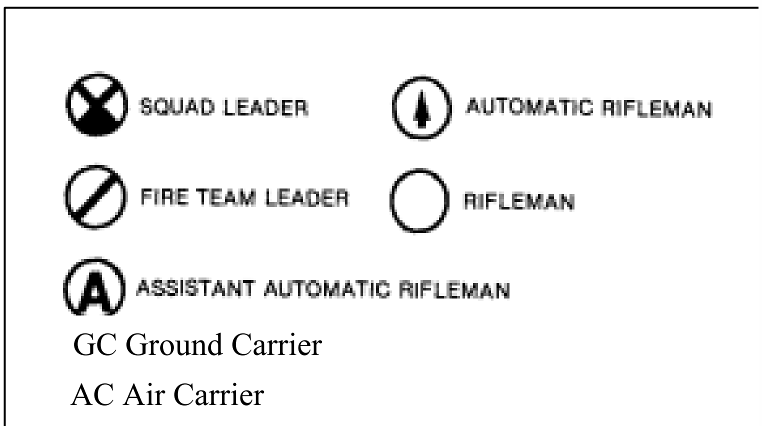


Figure 1-1. Marine Rifle Squad.

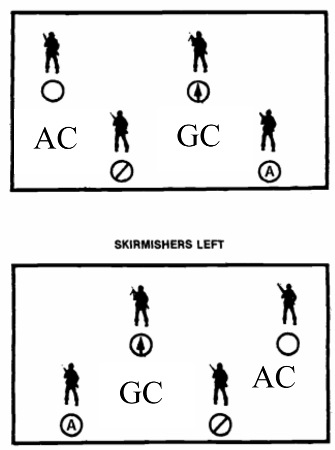
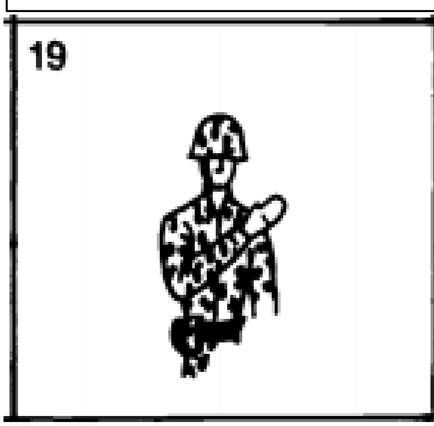
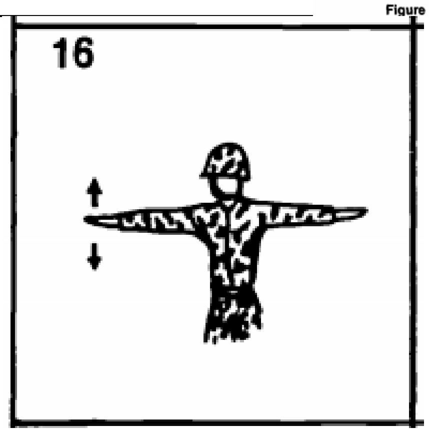


Figure 3-3. Fire Team Skirmishers.





Graphics derived from Ref 1.

Diagram 19 represents Fireteam Signal.

Diagram 16 represents represents Skirmishes Right Command (The mirror image is Skirmishes Left; Hand moving up and down signals Right or Left)

REFERENCE DOCUMENTS

1. MCWP 3–11.2 w/ ch1
2. MCO 3500.26

PLANNING FACTORS
THREAT ANALYSIS Omitted
CONDITIONS N/A
ASSUMPTIONS None
RESOURCES **1.** Small Tactical Unit **2.** UTACC **a.** User Interface System **b.** Air Carrier **c.** UAV 1 **d.** UAV 2 **e.** Ground Carrier **f.** UGV 1 **g.** UGV 2
SPECIFIED TASKS Conduct Fireteam Skirmishes movement in designated direction.
IMPLIED TASKS **1.** Provide persistent surveillance to support team movement. **2.** The relative position of the fire teams within the squad formation should be such that one will not mask the fire of the others. [Ref 1, Chap 3] **3.** It is not important that exact distances and intervals be maintained between fire teams and individuals as long as control is not lost. [Ref 1, Chap 3] **4.** Sight or voice contact will be maintained within the fire team and between fire team leaders and squad leaders. [Ref 1, Chap 3] **5.** All movement incident to changes of formation is usually by the shortest practical route. [Ref 1, Chap 3]
LIMITATIONS (CONSTRAINTS [C] AND RESTRAINTS [R]) None
SHORTFALLS None
UTACC ACTIONS
INPUTS **1.** UTACC generated 3D map **2.** team leader give hand and arm signal for wedge formation. **3.** team leader designates direction of movement **4.** team leader provides optional adjustment to initial positions of Carrier (Air, Ground). **5.** Initial sensor employment of Carrier (Air, Ground). **6.** Optional employment options for UGVs

PROCESS Air Carrier establishes its initial position behind the Riflemen even with the team leader Ground Carrier establishes its initial position behind the Automatic Riflemen even with the Assistant Automatic Riflemen.
OUTPUTS **1.** Refined 3D map **2.** Alert Updates (Enemy, Navigation, System status, ETC) **3.** (For example) 3D map update that makes route unpassable for UTACC ground systems. **4.** On demand Sensor data to Fireteam member display. **5.** On demand location and identification information for Enemy, fireteam members and UTACC components.
ASSOCIATED IER(s) **1.** IER SB-11 **2.** IER BF-03 **3.** IER CTP-02, 07 **4.** IER RP-05

SUPPLEMENTAL

High resolution versions of the following sections can be obtained by contacting the Naval Postgraduate School Dudley Knox Library:

Appendix B: Planning and Execution Model

Appendix C: Information Exchange Requirements

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